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MARINE ALGAE OF BRITISH COLUMBIA AND NORTHERN WASHINGTON, PART I: CHLOROPHYCEAE (GREEN ALGAE)

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MARINE ALGAE OF BRITISH COLUMBIA AND NORTHERN WASHINGTON, PART I: CHLOROPHYCEAE (GREEN ALGAE)

by Robert F. Scagel

Ottawa, 1966

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About this shore-hunting, however, many difficulties are apt to arise; among the foremost of which must be mentioned the risk of cold and destruction of clothes. The best pair of boots will not stand salt water many days—and the sea-weed collector who has to pick her way to save her boots will never be a loving disciple as long as she lives. It is both wasteful, uncomfortable, and dangerous to attempt sea-weed hunting in delicate boots. As for the hardier hunters who have learned to walk boldly into a pool if they suspect there is anything worth having in the middle of it, they will oil their boots. Next to boots comes the question of petticoats; and if anything could excuse a woman for imitating the costume of a man, it would be what she suffers as a sea-weed collector from those necessary draperies! But to make the best of a bad matter, let woollen be in the ascendant as much as possible; and let the petticoats never come below the ankle.

. . . MRS. ALFRED GATTY (1872)

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Résumé

Il s'agit de la première partie d'une étude minutieuse de la flore marine de la Colombie-Britannique et de la région septentrionale de l'État de Washington. Ce premier volume ne traite que des chlorophycées (algues vertes); il comprend une étude systématique de toutes les espèces et variétés de cette région. Il renferme les diagnoses avec illustrations de toutes les espèces connues; de plus, il fournit les clés systématiques au niveau des espèces et des variétés, de même que la clé artificielle des genres, ainsi qu'une bibliographie complète visant l'étude systématique. La région à l'étude se trouve en grande partie à l'intérieur de la province de la Colombie-Britannique; mais les recherches portent aussi sur les algues marines de la région septentrionale de l'État de Washington et de la partie méridionale de l'Alaska. L'étude systématique comprend l'appréciation critique de plusieurs genres, fondée sur une étude de spécimens-types et des travaux de recherches sur leur culture; elle porte sur plusieurs problèmes taxonomiques afférents aux stades de développement des algues vertes pléomorphes. Quarante-neuf planches de dessin graphique illustrent les espèces à l'étude.

INTRODUCTION

In an earlier publication the author (Scagel, 1957) presented an annotated list of the marine algae of British Columbia and Northern Washington. Keys to the genera of marine algae in the area were included, but a detailed systematic treatment of the species was not feasible at that time. To a larger extent the aim of this list was to present reference material from the literature, as well as from various herbaria, in order to give interested students and investigators a readily available source of information on the marine algae of the area. In addition to giving a historical outline of phycological activities it also served to report on the local distribution of species, new records and extensions in range based on recent collections, and to present up-to-date references on the synonymy of the marine algae in the northeast Pacific. At that time it was indicated that the list was intended only as a preliminary presentation dealing with the marine algae of British Columbia and Northern Washington until such time as a comprehensive manual could be undertaken. Since the appearance of this preliminary list there has been a considerable increase in interest and activity in the area, and many new records and further extensions in range have now come to light. Furthermore, in the intervening period the author has undertaken a more detailed study of the marine algae and has made a study of many of the types relating to species known to occur in the northeast Pacific. It is now possible, therefore, to prepare a more critical presentation of much of the marine algal flora of this region at the specific level. It is planned to produce a manual in three parts, each complete in itself with respect to diagnoses, keys, bibliography, and illustrations. The first of these, which is presented in the following pages, includes only species of green algae (Chlorophycophyta). The second and third parts, which will appear later, will comprise the brown algae (Phaeophycophyta) and the red algae (Rhodophycophyta).

It will be apparent to the student and reader, even in this more critical presentation of the marine Chlorophyceae, that there is still a great need for research of a monographic nature in this group. There have been several striking indications already, based on laboratory studies of living plants, of the significant potential that the culture approach has in clarifying the life histories and taxonomy of marine algae. There is a great need for more studies of living marine algae both in the field as well as under culture conditions. Certain very common genera, such as *Cladophora, Enteromorpha,* and *Ulva,* are notoriously difficult and cannot be adequately treated taxonomically until monographic studies, particularly from an ecological, cytological, and genetical point of view, have been undertaken. In a sense, then, even this more comprehensive treatment must be regarded as preliminary. But it is hoped that it will provide a useful source of information to phycologists and others interested in the marine algae of this region and, as the next step, encourage further studies on the marine algae of the northeastern Pacific.

This paper treats an area which is largely within the boundaries of the Province of British Columbia, but it also includes the marine algae from the northern part of the State of Washington and is equally comprehensive for the southern portion of the State of Alaska. A monographic treatment of many of the genera in these regions is still urgently needed.

Acknowledgments

I should like to express my sincere thanks to the many students, associates, and institutions that have contributed directly or indirectly in the progress of this work over a period of several years. I am particularly indebted to the National Research Council of Canada for the financial support which has enabled me to collect and observe marine algae extensively in the northeast Pacific and to study type specimens in European herbaria. In connection with various projects undertaken by the Institute of Oceanography and supported by the Defence Research Board, further valuable material has become available for study. In the early stages of this study the President's Research Fund of the University of British Columbia also provided financial support. To a large extent this presentation is based upon reference specimens deposited in the Phycological Herbarium of the University of British Columbia (UBC), but herbarium specimens have also been studied at a number of institutions in Canada, the United States, and Europe, and these are appropriately noted in the paper. The author is grateful to the numerous institutions that have extended loans of specimens or provided an opportunity to study their material. In this connection I would particularly like to acknowledge the loan of specimens and use of the phycological herbaria of the following: National Museum of Canada, Ottawa (CAN), Provincial Museum, Victoria (V), University of California, Berkeley (UC), New York Botanical Garden, New York (NY), University of Minnesota, Minneapolis (MIN), University of Washington, Seattle (WTU), Rijksherbarium, Leiden (L), Botaniska Trädgården och Botaniska Museet, Uppsala (UPS), Naturhistoriska Riksmuseet, Stockholm (S), Botaniska Museet, Lund (LD), Universitets Botaniske Museum, Copenhagen (C), Laboratoire de Cryptogamie, Muséum National d'Histoire Naturelle, Paris (PC), Royal Botanic Gardens, Kew (K), British Museum (Natural History), London (BM), Royal Botanic Gardens, Edinburgh (E), University of Glasgow (GL), Linnaean Society, London (LINN), Smithsonian Institution, Washington (US), and Trinity College, Dublin (TCD).

Unavoidable delay in publication since this paper was first submitted has made it impossible to revise completely in relation to all new information that has appeared since 1962. However, additions have been made, especially in the references, and footnotes have been added, in order to bring the manuscript up to date as far as practical.

KEY TO THE PHYLA OF MARINE ALGAE

1. Thallus distinctly green in colour because of the presence of unmasked chlorophylls; food reserves stored as starch .... CHLOROPHYCOPHYTA, p. 11
1. Thallus variously coloured because of the presence of accessory pigments masking the green pigments 2
    2. Thallus usually olive brown in colour owing to the presence of accessory pigments which mask the chlorophylls; reproduction at some stage typically involving biflagellate cells, with the flagella unequal in length and borne laterally .... PHAEOPHYCOPHYTA*
    2. Thallus not olive brown in colour 3
3. Thallus usually rose red, sometimes purplish or almost black (often fading and becoming somewhat greenish when growing in the intertidal zone); no reproductive stage with flagellated cells .... RHODOPHYCOPHYTA*
3. Thallus yellowish green in colour owing to the presence of accessory pigments; food reserves stored as oil (the only genera to be treated are *Vaucheria* and *Ostreobium*** which are multinucleate and have a non-septate, filamentous organization) .... CHRYSOPHYCOPHYTA*

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*To be published later in Parts II and III.

**According to Christensen (1962) and Parke and Dixon (1964) *Ostreobium* should be placed in the family Phyllosiphonaceae and referred to the order Chlorococcales.

SYSTEMATIC LIST

CHLOROPHYCEAE

- *VOLVOCALES*
  - VOLVOCINEAE
    - Polyblepharidaceae
      - *Stephanoptera*
        - *gracilis* (Artari) G. M. Smith
      - *Dunaliella*
        - *salina* (Dunal) Teodoresco
    - Pedinomonadaceae
      - *Thalassomonas*
        - *exurgens* Butcher
      - *Anisomonas*
        - *astigmatica* Scagel and Stein
    - Chlamydomonadaceae
      - *Tetraselmis*
        - *maculata* Butcher
      - *Brachiomonas*
        - *submarina* Bohlin
      - *Chlamydomonas*
        - *pulsatilla* Wohlenweber
  - CHLORODENDRINEAE
    - Chlorangiaceae
      - *Collinsiella*
        - *tuberculata* Setchell and Gardner
      - *Prasinocladus*
        - *lubricus* Kuckuck

- *ULOTRICHALES*
  - Ulotrichaceae
    - *Ulothrix*
      - *flacca* (Dillwyn) Thuret
      - *implexa* Kützing
      - *laetevirens* (Kützing) Collins
  - Chaetophoraceae
    - *Entocladia*
      - *viridis* Reinke
    - *Phaeophila*
      - *polymorpha* Jao
    - *Internoretia*
      - *fryeana* Setchell and Gardner
  - Ulvaceae
    - *Monostroma*
      - *arcticum* Wittrock
      - *fractum* Jao
      - *fuscum* (Postels and Ruprecht) Wittrock
        - var. *blyttii* (Areschoug) Collins
        - var. *fuscum*
        - var. *splendens* (Ruprecht) Rosenvinge

  - *oxyspermum* (Kützing) Doty
  - *zostericola* Tilden
- *Blidingia*
  - *minima* (Nägeli) Kylin
    - var. *minima*
    - var. *subsalsa* (Kjellman) Scagel
- *Enteromorpha*
  - *clathrata* (Roth) Greville
  - *compressa* (Linnaeus) Greville
    - var. *compressa*
  - *crinita* (Roth) J. Agardh
  - *intestinalis* (Linnaeus) Link
    - var. *clavata* J. Agardh
    - var. *cylindracea* J. Agardh
    - var. *intestinalis*
    - var. *maxima* J. Agardh
  - *linza* (Linnaeus) J. Agardh
    - var. *linza*
  - *marginata* J. Agardh
  - *prolifera* (Müller) J. Agardh
    - var. *prolifera*
  - *torta* (Mertens) Reinbold
  - *tubulosa* Kützing
- *Ulva*
  - *expansa* (Setchell) Setchell and Gardner
  - *fenestrata* Postels and Ruprecht
  - *lactuca* Linnaeus
    - var. *lactuca*
  - *rigida* C. Agardh
  - *vexata* Setchell and Gardner
- *Percursaria*
  - *percursa* (C. Agardh) Rosenvinge

SCHIZOGONIALES

Prasiolaceae

- *Schizogonium*
  - *murale* var. *uniseriatum* Jao
- *Prasiola*
  - *meridionalis* Setchell and Gardner
- *Rosenvingiella*
  - *constricta* (Setchell and Gardner) Silva

CLADOPHORALES

Cladophoraceae

- *Rhizoclonium*
  - *implexum* (Dillwyn) Kützing
  - *riparium* (Roth) Harvey
    - var. *riparium*
- *Lola*
  - *lubrica* (Setchell and Gardner) A. and G. Hamel

- *Urospora*
  - *mirabilis* Areschoug
    - var. *mirabilis*
  - *vancouveriana* (Tilden) Setchell and Gardner
  - *wormskjoldii* (Mertens) Rosenvinge
- *Chaetomorpha*
  - *californica* Collins
  - *cannabina* (Areschoug) Kjellman
  - *recurva* (Jao) *nom. nov.*
- *Cladophora*
  - *albida* (Hudson) Kützing
    - var. *albida*
  - *flexuosa* (Griffiths) Harvey
    - var. *flexuosa*
  - *glaucescens* (Griffiths) Harvey
  - *gracilis* (Griffiths) Kützing
    - var. *gracilis*
  - *hutchinsiae* (Dillwyn) Kützing
    - var. *distans* (C. Agardh) Kützing
    - var. *hutchinsiae*
  - *laetevirens* (Dillwyn) Kützing
  - *microcladioides* Collins
    - var. *microcladioides*
  - *stimpsonii* Harvey
  - *trichotoma* (C. Agardh) Kützing
    - var. *trichotoma*
- *Spongomorpha*
  - *arcta* (Dillwyn) Kützing
  - *coalita* (Ruprecht) Collins
  - *mertensii* (Ruprecht) Setchell and Gardner
    - var. *mertensii*
  - *saxatilis* (Ruprecht) Collins
    - var. *saxatilis*
  - *spinescens* Kützing

CHLOROCOCCALES

- CHLOROCOCCACEAE
  - *Chlorochytrium*
    - *inclusum* Kjellman
    - *porphyrae* Setchell and Gardner
  - *Codiolum*
    - *gregarium* A. Braun
      - var. *gregarium*
    - *petrocelidis* Kuckuck
- GOMONTIACEAE
  - *Gomontia*
    - *polyrhiza* (Lagerheim) Bornet and Flahault

CODIALES
  DERBESIACEAE
    Derbesia
      marina (Lyngbye) Solier
    Halicystis
      ovalis (Lyngbye) Areschoug
  CODIACEAE
    Codium
      fragile (Suringar) Hariot
        var. *fragile*
      ritteri Setchell and Gardner
      setchellii Setchell and Gardner
  BRYOPSIDACEAE
    Bryopsis
      corticulans Setchell
      plumosa (Hudson) C. Agardh

DESCRIPTIVE CATALOGUE

Class **CHLOROPHYCEAE** Kützing, 1845, p. 118.

The phylum Chlorophycophyta (Papenfuss, 1946, p. 218; 1955, p. 126) has only one class, the Chlorophyceae. The larger algae belonging to this group are found attached to the substratum in both the intertidal and subtidal zones, but they are more common in the former region. Some are microscopic and present in the plankton, but are less well known.

The Chlorophyceae vary in colour from a brilliant grass green to a paler, sometimes slightly yellowish green, because of the predominance of the green pigments, chlorophyll *a* and chlorophyll *b*, over the yellowish carotene and xanthophyll pigments.

The photosynthetic green pigments, as well as the associated or accessory pigments, are borne in chloroplasts which vary considerably in number, shape, and distribution in the cell. The chloroplasts usually contain one or more pyrenoids, and the photosynthetic reserves, which are usually stored as starch, are intimately associated with these organs.

The plants are unicellular, colonial, multicellular—filamentous, or parenchymatous—or non-septate and multinucleate; microscopic or macroscopic, occasionally reaching a length of more than a metre; and of definite or indefinite form. If the thallus is multicellular, growth is rarely initiated by apical cells, and the plants are either filamentous or non-filamentous (sometimes parenchymatous). If branched, the thallus may be regularly or irregularly divided.

Cells are uninucleate or multinucleate, and the nuclei are similar to those of higher plants. Some of the smaller unicellular plants have naked protoplasts, but there is usually a more rigid, sometimes laminated, wall next to the protoplast. This rigid wall is composed, either wholly or in part, of cellulose (except in some of the Codiales, where it is replaced by callose), and external to it is a layer of mucilaginous substances.

The vegetative methods of reproduction, including the various types of spores resulting from mitotic divisions, may involve haploid or diploid cells. Vegetative reproduction takes place by cell division and by fragmentation of the plant. Mitospores are also produced and may be motile (zoospores) or non-motile (aplanospores—spores which are produced within the original cell). Akinetes (non-motile, usually heavy-walled resting spores in which the outer wall of the original cell forms part of the wall of the spore) may also be formed. Zoospores usually have two or four equal length flagella of the whiplash type or, more rarely, several flagella arranged in a circle. In both instances the locomotor structures are usually restricted to the anterior end of the cell. One to many spores are produced within a cell or a sporangium, which may be a modified vegetative cell or a specialized cell.

The motile gamete (or gametes), usually biflagellate, is produced within a gametangium, which may be a modified vegetative cell or a specialized cell. The sex organs which are unicellular are freely exposed. The species may be unisexual or bisexual, and sexual reproduction is isogamous, anisogamous, or oogamous.

A number of different types of life history occur in the Chlorophyceae. In some species there is an alternation of morphologically and cytologically dissimilar generations with the conspicuous plant being a haploid gametophyte. In this type the zygote is the only diploid cell in the life cycle and, in some instances, it is known to divide meiotically to form one or more haploid motile or non-motile meiospores (zoospores or aplanospores) upon germination. This is the most common type of life history in freshwater green algae. In other species, the life history may include an alternation of morphologically and cytologically dissimilar generations with the conspicuous plant being a diploid sporophyte. The gametes are the only haploid cells in this type of life history, and meiosis takes place at gametogenesis. In a third type the life history may include an alternation of morphologically similar and cytologically dissimilar multicellular generations in which both gametophyte (or gametophytes, since instances of unisexual and bisexual species are known) and sporophyte generations are equally conspicuous. Also, less commonly, the life history may include an alternation of morphologically and cytologically dissimilar generations in which the gametophyte and sporophyte generations are both conspicuous, and in which the zygote germinates immediately to form the diploid spore-producing generation (sporophyte). Finally, there is the instance in *Prasiola* in which the vegetative plant is diploid and may produce diploid mitospores under some conditions. But under other circumstances the distal portion of the same thallus may undergo meiotic divisions to form a haploid region. This haploid region produces gametes, while the proximal vegetative region remains diploid—in effect, the gametophytic haploid tissue thus remains fastened to the sporophytic diploid phase.

In most instances the zygote in marine green algae is a thin-walled structure, which, depending upon the type of life history, upon germination directly produces one or more motile or non-motile meiospores (zoospores or aplanospores), or initiates the development of a juvenile thallus of the conspicuous sporophyte generation.

KEY TO THE ORDERS OF CHLOROPHYCEAE

1. Thallus unbranched or branched, non-septate and multinucleate; sometimes in the form of a spherical vesicle, sometimes filamentous with the filaments free from each other or interwoven to form a complex thallus .... CODIALES, p. 109
1. Thallus septate 2
  2. Thallus a simple or branched multicellular filament with multinucleate cells; chloroplasts usually small with many in a cell, usually disc-shaped; pyrenoids present .... CLADOPHORALES, p. 70
  2. Thallus otherwise 3
3. Thallus multicellular with uninucleate cells organized in a simple or branched filament, a membrane or a hollow tube; chloroplasts usually large, simple, and parietal with one to several in a cell; one to several pyrenoids present; cells sometimes with simple unicellular hairs .... ULOTRICHALES, p. 25
3. Thallus otherwise 4
  4. Thallus motile and unicellular in the vegetative condition, uninucleate, usually with a cup-shaped chloroplast .... (Volvocineae) VOLVOCALES, p. 13
  4. Thallus otherwise 5
5. Thallus unicellular (but frequently multinucleate) with cell-division absent in the vegetative condition; sometimes endophytic .... CHLOROCOCCALES, p. 102
5. Thallus otherwise 6
  6. Thallus multicellular (filamentous, membranous, or a solid cylinder); cells uninucleate, each with a single axile, stellate chloroplast .... SCHIZOGONIALES, p. 64

6. Thallus colonial (not filamentous), with cells arranged in a mucilaginous matrix, sometimes having a dendroid habit; vegetative cells non-flagellated . . . . (Chlorodendrineae) VOLVOCALES, p. 13

Order *VOLVOCALES* Oltmanns, 1904, p. 133.

Most of the genera placed in this order occur in fresh water, but when the marine nannoplankton have been more fully studied, members of the Volvocales may be found to be more numerous than at present recorded. Three somewhat artificial and not well demarcated suborders, of which only the Volvocineae and Chlorodendrineae are known to have representatives in this area, are recognized.

Plants unicellular or colonial; if colonial, non-filamentous; either motile throughout their vegetative existence, or temporarily forming palmelloid colonies of non-motile cells which readily revert to a motile phase; or non-motile, sedentary, unicellular or in dendroid colonies, with motility occurring only in connection with reproduction. Most genera have cells that are more or less ovoid, pyriform, or fusiform in shape; sometimes compressed or irregular in outline. The motile cells usually bear two, four, or eight flagella, usually of equal length, inserted at the anterior end of the cell. The cells are uninucleate. There is usually a single cup-shaped chloroplast in the cell with a single pyrenoid and, in motile forms, usually a single eyespot at the side of the chloroplast. Two contractile vacuoles are generally present in motile forms at the anterior end of the cell near the point of insertion of the flagella.

After continued division in the palmelloid condition, a large amorphous colony may be produced with many cells irregularly distributed throughout a mucilaginous matrix. The cells usually have a definite cell wall with a cellulose layer next to the protoplast and an outer thicker mucilaginous or pectic layer. In those motile forms which are naked, or lack a definite wall, the periplast, or peripheral portion of protoplasm, is rigid. In non-motile colonial forms the cells, which are provided with a membrane, may be held together only by the mucilaginous matrix in which they are embedded. Colonial forms may have cells irregularly distributed throughout, or at the periphery of microscopic or macroscopic colonies; the mucilaginous sheaths around the individual cells may be distinct or confluent and at times joined to one another to form a dendroid colony.

Reproduction usually occurs by longitudinal bipartition of the cell, or by repeated division of the protoplast to form two, four, eight, or sixteen motile mitospores (zoospores) with the same number of flagella as the motile vegetative cells; the flagella are equal in length. The zoospores are generally released following a mucilagination (breakdown) of the parent cell wall. Non-motile mitospores (aplanospores) and akinetes are also produced in some genera.

Sexual reproduction is isogamous, anisogamous, or oogamous. Motile gametes are biflagellate, with flagella equal in length.

The zygotes may be enveloped in thick walls and undergo a resting period, or they may be thin-walled and germinate immediately. In marine forms, as far as is known, the latter type is customary. The plants are apparently haploid in the vegetative condition with meiosis occurring on germination of the zygote and usually resulting in formation of motile meiospores (zoospores).

According to the classification system adopted in this paper (*see* p. 22 for further discussion), marine representatives belonging to two suborders, the Volvocineae and the Chlorodendrineae, are recorded from this area.

KEY TO THE FAMILIES OF VOLVOCALES

1. Plants unicellular and motile (flagellated) in the vegetative condition 2
1. Plants in the attached condition solitary or in branched colonies with the cells either terminal in a freely branched dendroid thallus or scattered in a mucilaginous matrix in a globose colony .... CHLORANGIACEAE, p. 22
    2. Plants with a definite, homogeneous cell wall .... CHLAMYDOMONADACEAE, p. 18
    2. Plants naked with an elastic periplast but without a definite wall 3
3. Cells more or less identical in shape in lateral and ventral views .... POLYBLEPHARIDACEAE, p. 14
3. Cells usually compressed, differing in lateral and ventral views .... PEDINOMONADACEAE, p. 16

Suborder VOLVOCINEAE West, 1916*a*, p. 161.

Plants unicellular or colonial, biflagellate or quadriflagellate with flagella usually of equal length; reproduction by motile mitospores (zoospores); sexual reproduction isogamous, anisogamous, or oogamous with biflagellate gametes; flagella usually equal in length.

KEY TO THE FAMILIES OF VOLVOCINEAE

1. Cell flagellated with a fine elastic periplast but no definite cell wall; cell division by longitudinal bipartition of the motile cell 2
1. Cell flagellated with a firm wall; vegetative division within a non-motile (sometimes motile) walled mother cell ...... CHLAMYDOMONADACEAE, p. 18
    2. Cells more or less identical in shape in lateral and ventral views; flagella equal in length .... POLYBLEPHARIDACEAE, p. 14
    2. Cells usually compressed, differing in lateral and ventral views; flagella unequal in length .... PEDINOMONADACEAE, p. 16

Family POLYBLEPHARIDACEAE (Blackman and Tansley) Oltmanns,* 1904, p. 135.

Polyblepharideae Blackman and Tansley, 1902, p. 22.

Plants unicellular; cells motile with two, three, four, five, or eight flagella of equal length; the flagella longer or shorter than the cell. Cells without a definite wall, but peripheral portion of the protoplasm being a rigid or elastic periplast permitting the cells to change slightly in shape as they swim, but at the same time always sufficiently rigid to give the cell a characteristic shape that may be recognized. Reproduction takes place while cells are in a motile condition by a longitudinal bipartition of the protoplast. Reproduction by motile mitospores (zoospores). Where known, sexual reproduction is isogamous; zygote germination usually results in formation of four meiospores (zoospores).

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*According to Christensen (1962) and Parke and Dixon (1964) this family, including *Stephanoptera*, should be transferred to the order Pyramimonadales in the class Prasinophyceae; and the genus *Dunaliella* should be placed in a separate family, the Dunaliellaceae, and retained in the Volvocales.

Key to the Genera of Polyblepharidaceae

1. Surface of motile cell with longitudinal keels or ridges; flagella of equal length and anterior in position .... STEPHANOPTERA, p. 15
1. Surface of motile cell without longitudinal ridges; flagella of equal length and anterior in position .... DUNALIELLA, p. 15

STEPHANOPTERA Dangeard, 1910, p. 991.

Unicellular, motile, according to the species two, four, or eight flagella, with the flagella of equal length; cells ovoid with longitudinal wings or keels which extend in the form of ridges from the posterior end of the cell toward the anterior end. Chloroplast cup-shaped, at the posterior end of the cell; eyespot and pyrenoid usually present.

Reproduction by longitudinal division of the protoplast to form two daughter individuals while in the motile condition.

Sexual reproduction unknown.

Morphology and Reproduction:

Artari, 1913, p. 455, 456, pl. 6, fig. III, 1–4 (as *Asteromonas*).
Dangeard, 1910, p. 991; 1912, p. II–X, pl. 1, figs. 1–25.
Butcher, 1959, p. 33–35, pls. II, fig. 9; VIII, fig. 3 (as *Asteromonas*).

Only one species is recorded from the area.

As at present circumscribed, the genus *Stephanoptera* is somewhat anomalous because it includes *species* with two, four, or eight flagella; whereas, in the Chlamydomonadaceae the presence of two versus four flagella is considered sufficiently important to distinguish *genera*.

Stephanoptera gracilis (Artari) G. M. Smith, 1933, p. 308.
Pl. 10, figs. G, H.

Unicellular, motile, and biflagellate; ovoid with acute apex and base; with six narrow longitudinal keels extending in the form of vertical or sometimes twisted ridges from the posterior end of the cell toward but not quite reaching the anterior end. In polar view appearing somewhat stellate in outline. Flagella about 1.5 to 2.0 times the length of the cell. Chloroplast cup-shaped with six vertical projections at the anterior end. Eyespot and pyrenoid present; contractile vacuoles absent. The cells 10–18 μ broad, 14–24 μ long.

References:

Artari, 1913, p. 455, pl. 6, fig. III, 1–4 (as *Asteromonas gracilis*).
Smith, 1933, p. 308, fig. 201; 1944, p. 27, pl. 1, fig. 2: 1950, p. 68, fig. 12.
Scagel, 1957, p. 31.
Butcher, 1959, p. 33 (as *Asteromonas gracilis*).

Habitat. In spray pools near high-tide mark.

Type Locality. Crimean Peninsula, Russia.

Pacific Coast Distribution. Northern Washington to Monterey, California.

DUNALIELLA Teodoresco, 1905, p. 230.

Plants unicellular, motile, ovoid to elliptical, sometimes compressed and sometimes tapering acutely to the anterior end; biflagellate with flagella equal in length. Chloroplast cup-shaped, at posterior end of cell; eyespot and one pyrenoid present.

Reproduction by longitudinal division of the motile cell.

Sexual reproduction isogamous with biflagellate gametes.

Morphology and Reproduction:

Teodoresco, 1905, p. 230, figs. 1–5, pls. 8, 9; 1906, p. 353–371, 409–427, figs. 1–25, pls. 6, 7, figs. 26–75.
Fritsch, 1935, p. 86, fig. 14B, p. 92, fig. 16C, p. 110, figs. 24A, B.
Lerche, 1937, p. 236–268, figs. 2–4, pls. 4–6.
Schooley and Pitelka, 1955, p. 88, pl. 22, fig. b.
Butcher, 1959, p. 20–24, pls. I, figs. 1–6; VII, figs. 1–6; XIV, fig. 2.

Only one species is recorded from the area.

Dunaliella salina (Dunal) Teodoresco, 1905, p. 230.
Pl. 10, fig. F.

Plants elliptical to ovoid, sometimes medianly constricted; apex acute or rounded; base rounded; chloroplast saucer-shaped with large sub-basal pyrenoid; elongate eyespot medianly situated; flagella 1.5 to 2.0 times as long as cell; cells also contain numerous fine refractive granules in a girdle just anterior to the chloroplast; chloroplast frequently masked by reddish haematochrome especially in older individuals. Cells 6–13 μ broad, 12–24 μ long.

Reproduction by longitudinal division of motile cells to form two daughter individuals.

Sexual reproduction isogamous with biflagellate gametes.

References:

Dunal, 1838, p. 172–174 (as *Haematococcus salinus* and *Protococcus salinus*).
Teodoresco, 1905, p. 230, figs. 1–5, pls. 8, 9; 1906, p. 353, figs. 1–25, pls. 6, 7, figs. 34–75.
Hamel, 1928, p. 4, fig. 1, A–C.
Smith, 1933, p. 308, fig. 202; 1944, p. 28, pl. 1, fig. 1; 1950, p. 70, fig. 13.
Lerche, 1937, p. 238–240, pl. 4, figs. 1–4, 5, figs. 1–4, 6, figs. 1, 2.
Scagel, 1957, p. 31.
Butcher, 1959, p. 21, pls. I, fig. 1; VII, fig. 5; XIV, fig. 1.

Habitat. In spray pools near high-tide mark.

Type Locality. Salt marsh on Mediterranean coast of France.

Pacific Coast Distribution. Northern Washington to Monterey, California.

Family PEDINOMONADACEAE Korschikov, 1938*a*, p. 47.
Protochlorineae Korschikov, 1923, p. 188.

Plants unicellular; cells motile with one or two flagella; flagella equal or subequal and both simple, or one simple and one with mastigonemes (tinsellated) or both with mastigonemes; the flagella usually arise from the middle portion of the long axis; chloroplast pale green or yellowish green to green; starch produced and pyrenoid usually present; cells without a definite wall, but peripheral portion of protoplasm being an elastic periplast permitting the cells to change in shape as they swim; eyespot usually present.

The genera included in the Pedinomonadaceae are of somewhat doubtful taxonomic position (Butcher, 1959, p. 36; Scagel and Stein, 1961, p. 1212). Despite the presence of starch as a reserve carbohydrate, they may, eventually, be more appropriately placed in the Xanthophyceae or Chrysophyceae because of their yellowish pigmentation and heterokont flagellation. However, until more is known of their biochemistry and reproduction, they are retained as a separate family in the Volvocales distinct from the Polyblepharidaceae. According to Parke and Dixon (1964) *Thalassomonas* (=*Micromonas*) and *Anisomonas* (=*Heteromastix*) should be placed in the family Nephroselmidaceae (order Pyramimonadales, class Prasinophyceae).

KEY TO THE GENERA OF PEDINOMONADACEAE

1. Flagella unequal or subequal; one simple, one with mastigonemes (tinsellated); pyrenoid present .... THALASSOMONAS, p. 17
1. Flagella unequal or subequal; both flagella simple; pyrenoid absent .... ANISOMONAS, p. 17

THALASSOMONAS Butcher, 1959, p. 39.

Plants unicellular, motile, orbicular to ovoid and somewhat compressed; biflagellate with the flagella unequal in length or subequal, usually arising from the middle portion of the long axis; the longer flagellum usually simple and the shorter one tinsellated; heterodynamic; chloroplast single, parietal with a single pyrenoid; eyespot present or absent.

Reproduction unknown.

Morphology and Reproduction:

Butcher, 1959, p. 39–41, pls. II, figs. 5, 6; VI, figs. 1–6; VIII, figs. 8–12; XIV, fig. 8.
Scagel and Stein, 1961, p. 122, figs. 13. 14.
Parke and Dixon, 1964, p. 529 (as *Heteromastix*).

Only one species is recorded for the area.

Thalassomonas exurgens Butcher, 1959, p. 41.
Pl. 10, fig. L.

Plant unicellular, naked, pale green in colour; cell somewhat reniform and concave, with a single cup-shaped parietal chloroplast, anterior reddish eyespot and a basal pyrenoid; 3 μ wide by 10 μ long; biflagellate, unequal, arising from an excentric infolding close to the eyespot; short flagellum simple, 1–2 μ long; long flagellum with mastigonemes (compound or tinsellated); appears to be heterotrophic.

References:

Butcher, 1959, p. 41, pls. VI, fig. 6; VIII, fig. 8.
Scagel and Stein, 1961, p. 1212, figs. 13, 14.

Habitat. Free swimming or floating in phytoplankton of inlets.

Type Locality. Isle of Sheppey, Kent, England.

Pacific Coast Distribution. Southern British Columbia.

ANISOMONAS Butcher, 1959, p. 38.

Plants unicellular, motile; compressed, ovoid to ellipsoid; biflagellate, heterodynamic; flagella unequal or subequal, usually arising from the middle portion of the longer axis, both simple; pyrenoid absent; starch stored.

Reproduction unknown.

Morphology and Reproduction:

Butcher, 1959, p. 38, 39, pls. VI, fig. 7; VIII, fig. 13.
Scagel and Stein, 1961, p. 1211, 1212, fig. 12.
Parke and Dixon, 1964, p. 529 (as *Micromonas*).

Only one species is recorded for the area.

Anisomonas astigmatica Scagel and Stein, 1961, p. 1211.
Pl. 10, fig. K.

Unicellular, naked, ovate, flattened at anterior end; 6 μ long by 10 μ wide; single cup-shaped chloroplast fills the cell, lacking pyrenoid, lacking eyespot; chloroplast filled with hyaline granules, occurrence of starch unknown; biflagellate, unequal, arise excentrically from flattened anterior end, shorter one close to cell, longer flagellum obvious and three times as long; probably isodynamic.

References:

Scagel and Stein, 1961, p. 1211, fig. 12.

Habitat. Free-swimming or floating in phytoplankton of inlets.

Type Locality. Indian Arm, a fjord at the head of Burrard Inlet, British Columbia.

Pacific Coast Distribution. Southern British Columbia.

Family CHLAMYDOMONADACEAE Stein *orth. mut.* G. M. Smith, 1920, p. 90.

Plants unicellular; cells motile with two or four flagella of equal length; the flagella usually longer than the cell. Cells variously shaped with a definite homogeneous cellulose wall. The flagella usually disappear before cell division, but reproduction may take place while cells are in the motile condition. Reproduction is by motile mitospores (zoospores) and two, four, or eight may arise from one cell. Where known, sexual reproduction is isogamous, anisogamous, or oogamous; motile gametes are usually biflagellate with the flagella equal in length; zygote germination usually results in formation of four or eight meiospores (zoospores). Some species are unisexual and others are bisexual.

KEY TO THE GENERA OF CHLAMYDOMONADACEAE

1. Cell quadriflagellate, slightly to distinctly flattened, and ovoid .... TETRASELMIS, p. 18
1. Cell biflagellate, uncompressed 2
    2. Cell subglobular, fusiform, ovoid or cylindrical, with wall extending to form an acute posterior horn and four others arranged in a cruciate manner about the anterior edges .... BRACHIOMONAS, p. 19
    2. Cell ovoid to globular, not with horns or lobes ... CHLAMYDOMONAS, p. 20

TETRASELMIS Stein, 1878, pl. 16.
Platymonas West, 1916*b*, p. 3.

Plant unicellular, yellowish green, usually motile, ellipsoid to ovoid, with a slight to distinct flattening; quadriflagellate, equal, arising from the base of an apical furrow at the anterior end. Cell wall more or less rigid; eyespot present.

Vegetative reproduction by division of the protoplast within mother cell, producing motile quadriflagellate daughter cells; aplanospores also reported.

Sexual reproduction unknown.

Tetraselmis (=*Platymonas*) is of questionable systematic position in the Chlorophyceae. Since it has mastigonemes (Pitelka and Schooley, 1955) on the flagella and a non-cellulosic cell wall (Lewin, 1958) it may, on further study, be more appropriately assigned to the Xanthophyceae. According to Christensen (1962) and Parke and Dixon (1964) it should be placed in a separate family, the Tetraselmidaceae (order Pyramimonadales, class Prasinophyceae).

Morphology and Reproduction:

Stein, 1878, pl. 16, figs. 1–3.
West, 1916*b*, p. 3, fig. 1 (as *Platymonas*).
Lewis and Taylor, 1921, p. 249–252, pl. 133, figs. 1–19.
Fritsch, 1935, p. 83, fig. 9, T; 12, J (as *Platymonas*).
Kylin, 1935*a*, p. 3, fig. 2 (as *Platymonas*).
Korschikov, 1938*a*, p. 133, 134, fig. 130 (as *Platymonas*).
Skuja, 1939, p. 159.
Smith, 1944, p. 29, 30 (as *Platymonas*).
Pitelka and Schooley, 1955, p. 88, pls. 22, fig. d; 24, figs. a, b (as *Platymonas*).
Lewin, 1958, p. 87–90, pl. 1, figs. 1–6 (as *Platymonas*).
Butcher, 1959, p. 61–71, pls. IV, figs. 4, 6–9; V, figs. 1–8; X, figs. 2–4, 7, 9–15, 17; XI, figs. 1–4, 7–14; XII, figs. 1–7; XIII, figs. 1–7.
Scagel and Stein, 1961, p. 1212.
Parke and Dixon, 1964, p. 529.

Only one species is recorded for the area.

Tetraselmis maculata Butcher, 1959, p. 67.
Pl. 11, figs. C–E.

Unicellular, cells 8–9 μ long, 5–7.5 μ in broadest dimension, somewhat compressed, ovate to elliptical, with a delicate cell wall; lobed at anterior end with an apical furrow in which arise four equal length flagella. Chloroplast yellowish green, with a single basal pyrenoid and a large eyespot in the lower half of the chloroplast.

Vegetative reproduction by division of protoplast to produce two quadriflagellate daughter cells (mitospores).

References:

Butcher, 1959, p. 67, pls. V, fig. 7; X, fig. 9; XI, fig. 12; XIII, fig. 6.

Habitat. In spray pools near high-tide mark.

Type Locality. Essex, Britain.

Pacific Coast Distribution. Southern British Columbia to Northern Washington.

BRACHIOMONAS Bohlin, 1897, p. 508.

Plant unicellular, motile, biflagellate, green, ovoid to globular; delicate rigid cell wall; flagella inserted at blunt anterior end. Cell wall at posterior end projecting out into an acute horn with four others arranged in a cruciform manner about the anterior edges. Chloroplast large, sometimes extending even to the tips of the horns, but usually not to the very end; with a single pyrenoid and a prominent, linear eyespot.

Vegetative reproduction occurs while cell is motile by division of the protoplast within the mother cell into two to eight daughter cells (mitospores) which are biflagellate at maturity; aplanospores have also been recorded.

Sexual reproduction is isogamous with eight to thirty-two biflagellate gametes produced; gametes differ slightly in shape, being somewhat simpler (less angular); plants unisexual; zygote is at first motile, later developing into a spherical zygospore which, on germination, produces four biflagellate zoospores (probably meiospores).

Morphology and Reproduction:

Bohlin, 1897, p. 508–510, figs. 1–3.
Hazen, 1922, p. 75–92, figs. 46–50, pls. 3, 4.
Hamel, 1928, p. 7, fig. 1, P–S.
Smith, 1933, p. 322, 323, fig. 214; 1950, p. 83, 84, fig. 27.
Fritsch, 1935, p. 83, 93, 95, figs. 7, O; 12, K, L; 16, E, F.
Droop, 1953, p. 25, figs. 1–11.
Butcher, 1959, p. 60, pls. II, fig. 8; IX, figs. 14, 15; XIV, fig. 7.

Only one species is recorded from the area.

Brachiomonas submarina Bohlin, 1897, p. 510.
Pl. 10, figs. I, J.

Unicellular, biflagellate; cells 15–40 μ long, 15–25 μ broad; pyramidal in shape with blunt or rounded anterior end; and posterior end extending into an elongate median acute horn, surrounded by four similarly elongate processes. Flagella arise from centre of rounded anterior end. Chloroplast green, single, parietal, filling the whole of the cell, sometimes also the horns; conspicuous pyrenoid and an elongate eyespot.

Vegetative reproduction occurs while cell is motile by division of the protoplast within the mother cell into two to eight daughter cells (mitospores), which are biflagellate at maturity; aplanospores have also been reported.

Sexual reproduction isogamous by biflagellate gametes; plants unisexual; gametes differing slightly in shape, being somewhat simpler (less angular). Zygote is at first motile, later developing into a spherical zygospore which, on germination, produces four biflagellate zoospores (probably meiospores).

References:

Bohlin, 1897, p. 510, figs. 2, 3.
Hazen, 1922, p. 75, pl. 3, figs. 1–27.
Smith, 1933, p. 322, fig. 214; 1950, p. 83, fig. 27.
Droop, 1953, p. 25, figs. 1–11.
Butcher, 1959, p. 60, pls. II, fig. 8; IX, fig. 15; XIV, fig. 7.

Habitat. In spray pools, near high-tide mark.

Type Locality. Near Stockholm, Sweden.

Pacific Coast Distribution. Southern British Columbia to Monterey, California.

CHLAMYDOMONAS Ehrenberg, 1835, p. 288.

Although this genus is widely represented in the freshwater habitat, comparatively few marine species have been described. The plant is unicellular and free swimming in the vegetative condition. It is spherical to ovoid in shape with two flagella of equal length inserted close together at the anterior end of the cell. The anterior end of the cell may or may not have a distinct papillate region. There is a definite cellulose wall layer.

The chloroplast is single, large, and usually cup-shaped; usually one pyrenoid is present, but some species have more than one. A single eyespot, usually near the anterior end, is present.

Vegetative reproduction by division of the protoplast to produce two, four, or eight (–64) biflagellate zoospores (mitospores) is of common occurrence; the same type of division may occur in a palmelloid condition; aplanospores and akinetes are also reported. The species may be unisexual or bisexual, and sexual reproduction may be isogamous, anisogamous, or oogamous. The motile gametes are terminally biflagellate with flagella of equal length. The number of gametes produced varies from species to species from four to thirty-two with a larger number of male gametes produced in the case of anisogamy.

Following fertilization, the zygote may remain motile for a few hours to several days, after which it usually becomes enveloped by a heavy wall. On germination, anteriorly biflagellate zoospores (meiospores) are produced, depending on the species, from four to thirty-two in number.

Morphology and Reproduction:

Ehrenberg, 1835, p. 288 (as *Chlamydomonas*).
Pascher, 1927, p. 173–312, figs. 130–280.
Smith, 1933, p. 315–317, fig. 208; 1950, p. 75–77, fig. 19.
Korschikov, 1938*b*, p. 5–7, pl. 1, figs. 11–13; pl. 2, figs. 14–19.
Gerloff, 1940, p. 311–502, figs. 1–48.
Lewin, 1957, p. 321–326, figs. 1–26.
Butcher, 1959, p. 47–60, pls. III, figs. 1–7; IV, figs. 1–3; IX, figs. 1–3, 5–13, 16; X, figs. 1, 4–6; XIII, figs. 8–17; XIV, figs. 3, 6, 9–11.

Only one species is recorded from the area, but many more will likely be encountered.

Chlamydomonas pulsatilla Wohlenweber, 1926, p. 56.
Pl. 11, figs. A, B.

Cells 15–29 μ long, 11–25 μ broad, slightly ovoid with a distinct anterior papilla; chloroplast filling most of cell with a more or less dissected anterior margin; single, spherical pyrenoid in lower half of cell; single eyespot centrally located; biflagellate with flagella passing through the margin of the papilla; flagella about 15 μ in length. Usually four contractile vacuoles at anterior end of cell.

Vegetative reproduction by division of protoplast to form two, four, eight, or sixteen biflagellate zoospores (mitospores); aplanospores may be produced.

References:

Wohlenweber, 1926, p. [52]–[56], pl. 2, figs. 1–22.
Butcher, 1959, p. 50, pls. IV, fig. 3; X, fig. 5; XIII, fig. 17.

Habitat. In rock spray pools.

Type Locality. In rock pools at Skay, near Lyngar, Norway.

Pacific Coast Distribution. Southern British Columbia.

According to Herndon's (1958) concept of the orders of Chlorophyceae, the Volvocales should be limited to those unicellular and colonial green algae which are motile during the vegetative phases of their life history. He has abandoned the Tetrasporales (=Tetrasporineae), in which order Smith (1950) places *Prasinocladus*, and suggests that most of the genera referred to this order should be placed in the Chlorococcales (the Chlorococcales are non-motile during the vegetative phases of their life history and lack the capacity for true vegetative cell division). Those green algae which possess vegetative cell division, form non-filamentous groups of cells, and produce zoospores he refers to the Chlorosphaeraceae in a separate order, the Chlorosphaerales. According to Herndon's concept of these orders, the genus *Prasinocladus* probably comes closest to the characteristics used to delimit the Chlorosphaeraceae or the Chlorococcales, but it is not entirely satisfactory in either of these groups. Thus, because of the present uncertain status of the marine members treated here in this section as members of the Volvocales (as well as those in the Chlorococcales, p. 102) no attempt is made to revise the classification until more information is available. It would seem, however, that the quadriflagellate nature of the zoospore of *Prasinocladus*, which is so very similar to *Tetraselmis* (p. 18), for example, in the Chlamydomonadaceae, is a strong point in favour of retaining the system of classification followed here. However, Chihara's (1963) report of tinsel flagella on the zoospores of *Prasinocladus ascus* Proskauer suggests that the genus should be removed entirely from the Chlorophyceae. (*See also* footnote on p. 24.)

Suborder CHLORODENDRINEAE Fritsch, 1935, p. 130.

Plants unicellular or colonial; cells non-motile; colonial types forming dendroid colonies; cells in some readily reverting to motile condition. A mucilaginous matrix in colonial forms may result in an extensive aggregation of cells. Cells with anterior end downward, chloroplast cup-shaped, at the posterior end of the cell; an eyespot may be present, and often contractile vacuoles; cell division produces two, four, or eight zoospores which may be liberated or, retaining the mucilaginous investment, may produce a branched colony; aplanospores formed in some genera; sexual reproduction, where known, by isogametes or anisogametes.

Family CHLORANGIACEAE Lemmermann, 1915, p. 25.

Plants sessile, unicellular, or colonial with cells in dendroid colonies; a mucilaginous investment and attached to substratum by a stalk-like modification of the sheath. Cell division produces two to eight motile mitospores (zoospores). Sexual reproduction isogamous with biflagellate gametes.

KEY TO THE GENERA OF CHLORANGIACEAE

1. Cells of colony mostly terminal in the free branches of a dendroid thallus .... PRASINOCLADUS, p. 24
1. Cells of colony embedded in a mucilaginous matrix; colony of irregular, tuberculate form .... COLLINSIELLA, p. 22

COLLINSIELLA Setchell and Gardner, 1903, p. 204.

Plant forming a solid or later hollow globose colony; colonies merging together to form a firm, dark green mucilaginous layer. The cells making up the colony are scattered throughout a mucilaginous matrix; they are pyriform in shape with the tapered end directed toward the interior of the colony. The cells are terminal on the branches of a more or less dichotomously branched system. The chloroplast is band-shaped or cup-shaped with a single, large pyrenoid.

Sexual reproduction occurs in surface cells only with from eight to sixteen biflagellate gametes resulting from the division of the protoplast.

Morphology and Reproduction:

Setchell and Gardner, 1903, p. 204, pl. 17, figs. 1–7; 1920*a*, p. 144, pl. 10, figs. 4–10.
Yendo, 1903, p. 199, pl. 8, figs. 1–15 (as *Ecballocystis*).
Wille, 1909, p. 28 (as *Ecballocystis*).
Chihara, 1958*a*, p. 307–313, figs. 1, 2; 1959, p. 193–201, figs. 1–5; 1960, p. 181–198, figs. 1–11; 1962, p. 44, 45.
Scagel, 1960*b*, p. 969–983, figs. 1–48.

Only one species is recorded from the area.

Collinsiella tuberculata Setchell and Gardner, 1903, p. 204.
Pl. 12, figs. A–E.

Plants forming tuberculate or globose colonies 2–4 mm in diameter, of a firm mucilaginous texture and bright green in colour. The cells are pyriform in shape, 5–12 μ broad and 12–20 μ long, and are borne at the tips of a radiately, more or less dichotomously branched system of stalks; the cells and stalks are embedded in a firm and extensive mucilaginous matrix.

References:

Collins, Holden and Setchell, 1902, XIX, No. 909.
Setchell and Gardner, 1903, p. 204, pl. 17, figs. 1–7; 1920*a*, p. 144, pl. 10, figs. 4–10.
Yendo, 1903, p. 199, pl. 8, figs. 1–15 (as *Ecballocystis willeana*).
Wille, 1909, p. 27, fig. 10, A–D (as *Ecballiocystis tuberculata*).
Collins, 1909*a*, p. 141, pl. IV, fig. 30; 1913, p. 101.
Smith, 1944, p. 31.
Doty, 1947, p. 5.
Scagel, 1957, p. 31; 1960*b*, p. 969, figs. 1–48.
Chihara, 1958*a*, p. 307, figs. 1, A, E, H, K; 2, A, D, G, J, L, O, R; 1960*a*, p. 186, figs. 2, A, B, D, G, J, M, P, S; 3, A–C, K, N; 4, 6.

Habitat. On stones in the middle intertidal zone.

Type Locality. Whidbey Island, Washington (UC 97694).

Pacific Coast Distribution. Southern British Columbia to Pacific Grove, California.

This genus has been the subject of recent studies by Chihara (1958*a*, 1959, and 1960*a*) and the author (Scagel, 1960*b*). Chihara found that all the Japanese species of *Collinsiella* produce biflagellate gametes, and in two of these (*C. cava* and *C. japonica*) he obtained a resting zygote which, on germination, produced quadriflagellate motile zoospores (meiospores?). He was unable, however, to get germination of the zygote in *C. tuberculata,* which is also found in Japan. Although the author (Scagel, 1960*b*), in culture studies of *C. tuberculata,* observed similar sexually reproducing plants which liberated biflagellate gametes similar to those found by Chihara, no resting zygote was obtained. Instead, the zygote germinated immediately to give rise eventually to a tubular thallus resembling *Enteromorpha.* Furthermore, this *Enteromorpha*-stage produced quadriflagellate motile cells at maturity. However, these quadriflagellate cells, after a period of motility, only produced similar tubular thalli. These zoospores are probably diploid mitospores (neutral spores of Bliding, 1933 and 1948). Although all these stages have been obtained repeatedly, the cycle has still not been completed and requires cytological study before any additional conclusions can be drawn. The evidence would indicate, however, that *Collinsiella tuberculata* is merely a stage in the life history of a species of *Enteromorpha,* probably *E. intestinalis* (*see* p. 51).

PRASINOCLADUS Kuckuck,[*] 1894, p. 261.

Plants composed of a dichotomously branched system of filaments making up a dendroid colony of cells. The cells are borne in terminal segments on the branches of the colony, and the stalk system is transversely septate. The cells are elliptical with the anterior end toward the stalk, and the protoplast slides within the sheath at the time of division. The chloroplast is cup-shaped, and lobed at the anterior end; it is situated toward the posterior end of the cell. The cells have a single pyrenoid and an eyespot.

At times the cell at the end of the filament divides longitudinally into two daughter protoplasts, each of which then becomes the initial of a new branch; or division of the protoplast may result in two quadriflagellate motile mitospores (zoospores). The zoospores may remain within the filament and add to its development, or they may escape, settle down, and develop into new filamentous colonies. Aplanospores may also be formed.

Sexual reproduction is unknown.

Morphology and Reproduction:

Davis, 1894, p. 377–390, pl. XIX, figs. 1–12 (as *Euglenopsis*).
Kuckuck, 1894, p. 261, 262, fig. 28.
Dangeard, 1912, p. 10, pl. 2, figs. 1–13.
Hamel, 1928, p. 9, fig. 2, G, H.
Oltmanns, 1922, p. 241, fig. 160.
Zimmerman, 1923, p. 286–289, pl. 1, fig. 2, a–e.
Lambert, 1930, p. 227–244, figs. 1–4.
Fritsch, 1935, p. 132, fig. 35, D, G, H.
Kylin, 1935*a*, p. 7–12, fig. 3.
Chihara, 1963, p. 17–28, figs. 1–3.
Proskauer, 1950, p. 59–66, figs. 1–40.

Only one species is recorded from the area.

Prasinocladus lubricus Kuckuck,[**] 1894, p. 261.

Pl. 11, figs. F–H.

Plants occurring in tufts or forming a continuous thin green coating, with the filaments up to 250 μ long, the branching repeatedly dichotomous; cells elliptical, 5–9 μ broad, 12–20 μ long, and segments barrel-shaped, 6–8 μ broad and 12–32 μ long.

References:

Kuckuck, 1894, p. 261, fig. 28.
Collins, Holden and Setchell, 1899, XII, No. 564 (as *P. subsalsus*).
Oltmanns, 1904, p. 86, figs. 1–7 (as *Chlorodendron subsalsum*).
Collins, 1909*a*, p. 141 (as *P. subsalsus*).
Zimmerman, 1923, p. 286, fig. 2, a–e.
Newton, 1931, p. 54, fig. 38.
Smith, 1933, p. 365, fig. 246; 1944, p. 32, pl. 1, fig. 3; 1950, p. 130, fig. 68.
Taylor, 1937, p. 38; 1957, p. 38.
Kylin, 1949, p. 6, fig. 2, G–K; p. 7, fig. 3, A–H.
Scagel, 1957, p. 32.

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[*] According to Christensen (1962) and Parke and Dixon (1964) *Prasinocladus* should be placed in a separate family, the Chlorodendraceae (order Pyramimonadales) and transferred to the class Prasinophyceae.

[**] According to Waern (1952) and Chihara (1963) this species should now be referred to as *P. marinus* (Cienkowski) Waern.

Habitat. On cement tanks and aquaria in seawater system at Friday Harbor Laboratories.

Type Locality. On the walls of culture vessels, Helgoland, Germany.

Pacific Coast Distribution. Friday Harbor, Washington, to Monterey, California.

Order *ULOTRICHALES** Borzi, 1895, p. 348 (as Ulothrichiales).

The order Ulotrichales comprises chiefly freshwater species, but there are some genera with both freshwater and marine species, and others that are strictly marine.

The plants are multicellular, filamentous (made up of a uniseriate or biseriate rows of cells), either branched or unbranched, or they may be non-filamentous, tubular, or flattened and membranous (foliose). There may or may not be a differentiation of the thallus into an attached basal and an erect, free distal portion. The plants may be attached or free-floating. In some cases the thallus may be considerably reduced or condensed and may be either unicellular or, by irregular division, appear as a pseudoparenchymatous disc or plate of cells in which the cells or filaments are so crowded that the branching habit is obscured; or it may be prostrate and attached by a part of or the entire lower surface. In some instances, in branched forms, the thallus is differentiated into an attached prostrate, creeping, and an erect, free system of branches.

The cells are uninucleate (rarely multinucleate) and have a distinct wall with a well-developed inner cellulose layer next to the protoplast and an outer mucilaginous layer; they usually contain a single, parietal, laminate or plate-like, entire or perforate, sometimes cup-shaped chloroplast, and at least one and sometimes several pyrenoids.

Vegetative reproduction by fragmentation may occur in some instances; reproduction also takes place by motile (zoospores) or non-motile (aplanospores and akinetes) mitospores and motile meiospores (zoospores); the zoospores are always naked with a posterior chloroplast and with an eyespot at the anterior end; usually biflagellate, but sometimes quadriflagellate, with flagella always of equal length; the mitospores may be formed within modified vegetative cells or within distinctive sporangia; from one to thirty-two spores may be produced in a sporangium.

Sexual reproduction is isogamous, anisogamous, or oogamous; the gametes are usually biflagellate (at times apparently quadriflagellate) with flagella of equal length; the gametes may be produced within modified vegetative cells or within distinctive gametangia; from eight to sixty-four gametes are produced in the gametangium.

At maturity zoospores and gametes may be liberated through a pore, or there may be a more extensive breakdown of the cell wall.

The zygote may develop immediately into a multicellular thallus, or, especially in freshwater species, it may secrete a thick wall and, following a period of dormancy, germinate to produce quadriflagellate motile meiospores (zoospores).

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*In a recent paper Kornmann (1965) proposes including three families (Ulotrichaceae, Codiolaceae, and Monostromaceae) in the order Ulotrichales; and in the same paper in a footnote he modifies this proposal and places the Codiolaceae in a new order, Codiolales.

Certain genera have a life history with a multicellular gametophyte alternating with a single-celled diploid phase (zygote). But others are isomorphic, and a few are known to have an alternation of multicellular heteromorphic generations. In some instances an alternation of isomorphic generations occurs in some species, whereas other species in the same genus are haplobiontic.

KEY TO THE FAMILIES OF ULOTRICHALES

1. Plants filamentous at maturity 2
1. Plants not filamentous; at maturity a biseriate thallus, a branched or an unbranched tube, or a monostromatic or distromatic membrane (either saccate or a uniseriate filament when young) .... ULVACEAE, p. 32
  2. Filaments usually unbranched and without hairs ... ULOTRICHACEAE, p. 26
  2. Filaments branched, often bearing simple hairs .. CHAETOPHORACEAE, p. 29

Family ULOTRICHACEAE Kützing *orth. mut.* Rabenhorst, 1868, p. 298, 360.

Ulothricheae Kützing, 1843, p. 251.

Plants in this family are filamentous, composed of a uniseriate row of cells, unbranched, or rarely branched, with or without a differentiated basal attachment; sessile or free-floating. Filaments with or without a thin, mucilaginous outer layer; with cellulose layer next to the protoplast; cells cylindrical to spherical, uninucleate, with a single, parietal, plate-like, or band-like chloroplast, with one to several pyrenoids.

Vegetative reproduction may occur by fragmentation; reproduction also takes place by motile (zoospores) and non-motile (aplanospores and akinetes) mitospores and motile meiospores (zoospores); zoospores are biflagellate or quadriflagellate with flagella of equal length; from two to sixteen are produced in the sporangium; spores are formed within modified cells not differentiated from the vegetative cells, and escape through a pore in the cell wall.

Sexual reproduction is isogamous or anisogamous; gametes are biflagellate, with flagella of equal length; gametes are formed within modified vegetative cells and escape through a pore in the cell wall; on germination the zygote usually produces 4 to 16 quadriflagellate meiospores (zoospores).

Only one genus, *Ulothrix*, in the family Ulotrichaceae is represented in the local flora.

ULOTHRIX Kützing, 1833, p. 517.

Plants filamentous and generally unbranched, usually attached by an elongated basal holdfast cell; cells cylindrical, frequently as short as broad or shorter. Cells uninucleate; chloroplast a parietal band completely or incompletely circling the cell, with one to several pyrenoids. According to the species, the chloroplast extends the whole length of the cell or occupies only a part of the length. Both freshwater and marine species. All cells but the basal rhizoidal cell may become fertile.

Vegetative reproduction occurs by fragmentation; reproduction also occurs by motile (quadriflagellate zoospores) and non-motile (aplanospores and akinetes) mitospores. One, two, four, eight, sixteen, or thirty-two mitospores are produced per cell; they have a conspicuous red eyespot and are liberated through a lateral pore in the cell wall.

Sexual reproduction occurs by biflagellate isogametes; there are eight, sixteen, thirty-two, or sixty-four gametes produced in each gametangium. The plants are generally unisexual.

The plants are haploid as far as known, and meiosis occurs on germination of the zygote; from four to sixteen motile (zoospores) or non-motile (aplanospores) meiospores are produced. On germination and after subsequent mitotic divisions, the meiospores result in new haploid filaments.

Morphology and Reproduction:

Kützing, 1833, p. 517.
Dodel, 1876, p. 417–541, pls. 31–38.
Hazen, 1902, p. 145–158, pls. 20, figs. 1–9; 21, figs. 1–7.
Grosse, 1931, p. 206–234, figs. 1–20.
Kornmann, 1963*a*, p. 357–360, figs. 1–2; 1963*b*, p. 60–68, fig. 1; 1964*a*, p. 27–38, figs. 1–8; 1965, p. 163–172, fig. 1.

Setchell and Gardner (1920*a*) emphasized the need for a study of the species of this genus in culture. They commented on the variations in cell size and chloroplast at different ages, under different environmental conditions, and in the sterile and reproductive phases (*see also* Hare, 1961). A *Codiolum*-stage has been described by Kornmann (1963*a*) from a cultural study of a marine species of *Ulothrix*. This stage develops from a germinating quadriflagellate zoospore and, after several weeks, produces quadriflagellate zoospores. Such a study has still not been undertaken in this area; hence, it is not possible at this time to evaluate the genus more critically than can be done using the criteria that have been used in the past to distinguish species. For this reason, I have attempted to evaluate and base specific diagnoses essentially on data available and after a review of the work of Hazen (1902), Collins (1909*a*), and Setchell and Gardner (1920*a*).

Key to Species of Ulothrix

1. Chloroplast usually an incomplete ring occupying only the middle part of the cell; filaments 5–15 μ in diameter, cells nearly quadrate, but sometimes about half as long as broad .... *U. implexa,* p. 28
1. Chloroplast usually an incomplete ring occupying nearly or the complete length of the cell; cells generally much broader than long 2
   2. Filaments free and without branches; chloroplast sometimes a complete ring .... *U. flacca,* p. 27
   2. Filaments in tufts, tending to be compactly united near the base; chloroplast usually an incomplete ring .... *U. laetevirens,* p. 29

Ulothrix flacca (Dillwyn) Thuret, *in* LeJolis, 1863, p. 56.
Pl. 16, figs. C–H.

Filaments bright to dark green in colour, in short tufts or often in long entangled skeins; filaments 10–25 μ in diameter with cells almost quadrate when young, becoming shorter when older, and measuring 0.25–0.75 times as long as broad (usually 10–15 μ in length) in the mature vegetative condition; often swollen at the middle of the cell to 50–60 (–80) μ when fertile. Chloroplast occupying the whole length of the cell with usually one pyrenoid (sometimes up to three or more, especially prior to formation of mitospores); chloroplast an incomplete band, or often appearing as a complete ring.

References:

Dillwyn, 1809, p. 187, pl. 49 (as *Conferva flacca*).
Kützing, 1845, p. 204; 1849, p. 381 (as *Hormotrichum flaccum*).
Thuret, *in* LeJolis, 1863, p. 56.
Hauck, 1885, p. 442.
Collins, Holden and Setchell, 1895, I (No. 17); 1903, XXII (No. 1123).
Saunders, 1901, p. 417.
Hazen, 1902, p. 155, 156, pl. 20, figs. 7–9.
Setchell and Gardner, 1903, p. 217; 1920*a*, p. 284.
Collins, 1909*a*, p. 185.
Hamel, 1928, p. 20, fig. 6, A–D.
Newton, 1931, p. 56, fig. 40.
Levring, 1935, p. 5; 1937, p. 16.
Taylor, 1937, p. 46, pl. 1, fig. 9; 1957, p. 45, pl. 1, fig. 9.
Sanborn and Doty, 1947, p. 19.
Doty, 1947, p. 5.
Kylin, 1949, p. 12.
Chapman, 1956, p. 376, fig. 16a.
Scagel, 1957, p. 32.

Habitat. On other algae, rocks, and wood in the intertidal zone (frequently in the upper region).

Type Locality. Swansea, Wales (*Conferva flacca*).

Pacific Coast Distribution. St. Michael, Alaska, to California.

Ulothrix implexa Kützing,* 1849, p. 349.
Pl. 16, figs. I, J.

Filaments in soft, silky, yellowish green tufts, up to 3 cm long, attached or free-floating; often in entangled masses; filaments 5–15 μ in diameter with cells almost quadrate (sometimes slightly swollen at the middle) when young, becoming shorter when older, and measuring 0.5 to 1.0 times as long as broad (usually 5–10 μ in length) in the mature vegetative condition; fertile cells almost quadrate and only slightly, if at all swollen. Chloroplast an incomplete band, usually occupying only the middle part of the cell and containing one pyrenoid.

References:

Kützing, 1847, p. 177 (as *Hormidium implexum*); 1849, p. 349.
Hauck, 1885, p. 440, fig. 193.
DeToni, 1889, p. 168 (as *Hormiscia implexa*).
Collins, Holden and Setchell, 1895, III (No. 115); 1905, XXVI (No. 1275) (as *U. subflaccida*).
Wille, 1901, p. 27, pl. 3, figs. 90–100 (as *U. subflaccida*).
Hazen, 1902, p. 153–155, pl. 21, figs. 1, 2.
Setchell and Gardner, 1903, p. 217; 1920*a*, p. 283.
Collins, 1909*a*, p. 185; p. 186 (as *U. subflaccida*).
Newton, 1931, p. 55.
Taylor, 1937, p. 47; 1957, p. 46.
Smith, 1944, p. 34, pl. 1, figs. 4, 5.
Doty, 1947, p. 5.
Waern, 1952, p. 30 (as *U. subflaccida*).

**Ulothrix implexa* has been rejected by Womersley (1956, p. 349) and the plant has been referred to *U. pseudoflacca* Wille as the type of the former is stated not to include any *Ulothrix*. Both *U. pseudoflacca* and *U. flacca* have been reported from the Pacific Coast (Setchell and Gardner, 1920*a*, p. 284, 285) but until the genus has been studied more critically, it is impossible to distinguish between these on the basis of information available.

Womersley, 1956, p. 349 (as *U. pseudoflacca*).
Chapman, 1956, p. 376, fig. 16b (as *U. subflaccida*).
Scagel, 1957, p. 33.

Habitat. On rocks and wood in the intertidal zone, usually near the mouths of streams.

Type Locality. Near Goes, Netherlands (L. No. 938,174 . . . 397, as *Hormidium implexum*).

Pacific Coast Distribution. Bering Sea to Monterey, California.

Ulothrix laetevirens (Hooker) Collins, 1909*a*, p. 186.
Pl. 16, figs. K–M.

Filaments entangled and creeping, often with several filaments compactly united near the base into a pseudoparenchymatous mass; filaments occasionally branching, often almost at right angles, with cells of branch being more slender than the supporting axis; main filaments 10–25 μ in diameter and measuring 0.25 to 0.75 times as long as broad (usually 5–10 μ in length) in the mature vegetative condition; fertile cells only slightly, if at all, swollen. Chloroplast usually an incomplete band covering almost the complete length of the cell and containing one pyrenoid.

References:
Hooker, 1833, p. 317 (as *Bangia laetevirens*).
Harvey, 1841, p. 173 (as *Bangia laetevirens*).
Kützing, 1845, p. 194; 1849, p. 351; 1852, p. 32, pl. 100 (as *Schizogonium laete virens*).
Wille, 1901, p. 25, pl. 2, figs. 82–89; 1906*b*, p. 12, pl. 1, figs. 30, 31 (as *U. consociata*).
Collins, 1909*a*, p. 186.
Setchell and Gardner, 1920*a*, p. 286.
Taylor, 1937, p. 46; 1957, p. 46.
Scagel, 1957, p. 33.

Habitat. On old wood in the intertidal zone.

Type Locality. Calvados, France (*Bangia laetevirens* Harvey).

Pacific Coast Distribution. Unalaska Island, Alaska, to California.

Family CHAETOPHORACEAE (Greville) Harvey, *corr.* Stizenberger,* 1860, p. 34.

Chaetophoroideae Greville, 1824, p. 321.
Chaetophoroideae Harvey, 1841, p. 10.

Plants usually branched and filamentous, with branches consisting usually of a uniseriate series of cells, erect or creeping; frequently with an erect system of branches arising from a pseudoparenchymatous basal prostrate system made up of laterally compacted branches; sometimes prostrate, attached by a part of or the entire lower surface; narrow hyaline hairs frequently present as terminal extensions of one or more cells.

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*According to some authors this family should be placed in a separate order, the Chaetophorales.

Cells uninucleate (or rarely multinucleate) with a single laminate or annular, sometimes dissected, parietal chloroplast with one or more pyrenoids.

Vegetative reproduction may take place by fragmentation; reproduction also occurs by motile (zoospores) or non-motile (aplanospores and akinetes) mitospores and motile meiospores (zoospores); zoospores are biflagellate or quadriflagellate, with the flagella of equal length; from two to sixteen or more zoospores are formed in the sporangium; mitospores are produced within undifferentiated vegetative cells.

Sexual reproduction is usually isogamous, rarely anisogamous or oogamous, gametes biflagellate or apparently rarely quadriflagellate, with flagella of equal length; produced within undifferentiated vegetative cells. On germination the zygote usually produces four quadriflagellate meiospores (zoospores).

KEY TO THE GENERA OF CHAETOPHORACEAE

1. Cells bearing from one to three simple, long, colourless hairs .... PHAEOPHILA, p. 31
1. Cells not bearing hairs 2
    2. Thallus forming a profusely branched, anastomosing filament within the membrane of *Smithora naiadum* .... INTERNORETIA, p. 32
    2. Thallus forming small patches of irregularly branched filaments radiating from a common centre; endophytic in the outer cell walls of various algae .... ENTOCLADIA, p. 30

ENTOCLADIA Reinke, 1879, p. 476.

Plants microscopic, occurring as creeping, branched filaments, usually free but sometimes compacted and pseudoparenchymatous; usually within, rarely upon, the walls of various algae, aquatic spermatophytes and animals, and in dead shells. Hairs and setae absent. Cells uninucleate. Cells possess a single, parietal, plate-like or band-like chloroplast with one to several pyrenoids.

Reproduction occurs by quadriflagellate (biflagellate also reported) zoospores and akinetes produced in cells toward the centre of the plant; usually eight zoospores are produced in each undifferentiated sporangium.

Sexual reproduction is uncertain, but has been reported to be by biflagellate isogametes, with eight to sixteen gametes produced in the gametangium.

Morphology and Reproduction:

Reinke, 1879, p. 476–478, pl. 6, figs. 6–9.
Wille, 1890, p. 94, fig. 57 (as *Entoderma*).
Huber, 1892, p. 313–326, pls. 14, 15 (as *Endoderma*).
Borzi, 1895, p. 291–301, pl. 15 (as *Entoderma*).
Setchell and Gardner, 1920*a*, p. 288–292, pls. 19, fig. 7; 18, fig. 7.
Hamel, 1928, p. 38, figs. 13, A–D; 14, A–C.
Kylin, 1935*b*, p. 197–204, figs. 5–7.
Anand, 1937, p. 12–16, figs. 1, 2 (as *Endoderma*).

Entocladia viridis Reinke, 1879, p. 476.
Pl. 17, fig. C.

Plants endophytic within the outer cell walls of various algae; filamentous, freely branched; the centre of the mature plant does not have a pseudoparenchymatous organization. The cells are variable in shape, sometimes swollen and contorted; those at the periphery are cylindrical and those at the apices of the filaments are blunt. The cells at the periphery are usually 5–10 μ in diameter; they are one to six times as long as wide (usually about 25 μ in length). Fertile cells are usually larger and several cells from the periphery; they may be up to 20 μ in diameter and 40 μ in length.

References:

Reinke, 1879, p. 476–478, pl. 6, figs. 6–9.
Lagerheim, 1883, p. 74.
Hauck, 1885, p. 462, fig. 198.
DeToni, 1889, p. 209 (as *Endoderma viride*).
Oltmanns, 1904, p. 232, fig. 147.
Collins, 1909*a*, p. 279 (as *Endoderma viride*); 1913, p. 103 (as *Endoderma viridis*).
Collins, Holden and Setchell, 1910, XXXIII (No. 1626); 1915, XLI (No. 2006), 1917, XLV (No. 2236) (as *Endoderma viride*).
Howe, 1914, p. 27 (as *Endoderma viride*).
Setchell and Gardner, 1920*a*, p. 289.
Hamel, 1928, p. 38, fig. 13, A–D (as *Endoderma viride*).
Newton, 1931, p. 62 (as *Endoderma viride*).
Levring, 1935, p. 10 (as *Endoderma viridis*); 1937, p. 25.
Taylor, 1937, p. 53, pl. 2, figs. 1, 2; 1957, p. 54, pl. 2, figs. 1, 2.
Anand, 1937, p. 12 (as *Endoderma viridis*).
Smith, 1944, p. 35.
Kylin, 1949, p. 38, fig. 39.
Chapman, 1956, p. 435, fig. 87.
Scagel, 1957, p. 33.
Levring, 1960, p. 12.

Habitat. Endophytic in *Callithamnion pikeanum, Delesseria decipiens,* and other algae in the lower intertidal and subtidal zones.

Type Locality. Naples.

Pacific Coast Distribution. Southern British Columbia to Monterey, California, and in the Galapagos Archipelago and Chile.

PHAEOPHILA Hauck, 1876, p. 57.

Thallus epiphytic or endophytic, an irregularly branched uniseriate filament. Cells with one to three long, non-septate, simple processes or hairs; cells with lobed parietal chloroplasts and several pyrenoids.

Reproduction by quadriflagellate zoospores produced usually in slightly enlarged and often terminal cells; aplanospores also reported.

Morphology and Reproduction:

Hauck, 1876, p. 57, fig. 1; 1885, p. 464, fig. 200.
Huber, 1892, p. 327–332, pl. 16.
Hamel, 1928, p. 25, fig. 7, A–E.
Newton, 1931, p. 58, fig. 43.
Kylin, 1935*b*, p. 193–197, figs. 3, 4; 1949, p. 33, fig. 35.
Taylor, 1937, p. 51, pl. 2, figs. 4, 5; 1957, p. 50, 51, pl. 2, figs. 4, 5.

Phaeophila polymorpha Jao, 1937, p. 100.
Pl. 17, fig. B.

Thallus on or within the superficial layers of empty shells; an irregularly branched filament of cells; cells irregular and frequently swollen, 5–10

(–20) μ in diameter and 20–85 (–180) μ long; hairs simple, undulate, colourless, one to three arising from a cell; hairs separated by a wall at maturity from cell below.

The cells contain a single laminate, parietal chloroplast with several pyrenoids.

Zoospores formed in undifferentiated terminal or intercalary cells.

References:
Jao, 1937, p. 100, pl. 12, figs. 7–10.
Scagel, 1957, p. 33.

Habitat. In empty shells in the intertidal zone.

Type Locality. Argyle Lagoon, San Juan Island, Washington.

Pacific Coast Distribution. Northern Washington.

INTERNORETIA Setchell and Gardner, 1920*b*, p. 294.

Thallus of profusely branched filaments, at first uniseriate but eventually becoming multiseriate and giving rise to cylindrical branches several cells in diameter as a result of transverse, longitudinal, and oblique divisions; endophytic.

Chloroplast parietal with one pyrenoid.

Reproduction unknown.

Morphology and Reproduction:
Setchell and Gardner, 1920*a*, p. 294, 295, pl. 18, figs. 3–6; 1920*b*, p. 294, 295, pl. 23, figs. 3–6.
Scagel, 1957, p. 34.

Internoretia fryeana Setchell and Gardner, 1920*b*, p. 295.
Pl. 17, fig. A.

Thallus a branched filament, at first uniseriate but eventually becoming multiseriate, three to five cells in thickness and forming an anastomosing network of cylindrical branches. Cells 3–5 μ in diameter and 10–15 μ in length. Chloroplast parietal with generally one pyrenoid.

References:
Setchell and Gardner, 1920*a*, p. 295, pl. 18, figs. 3–6; 1920*b*, p. 295, pl. 23, figs. 3–6.
Scagel, 1957, p. 34.

Habitat. Endophytic in *Smithora naiadum.*

Type Locality. Friday Harbor, Washington (Type UC 314961).

Pacific Coast Distribution. Northern Washington.

Family ULVACEAE Lamouroux *orth. mut.* Dumortier, 1822, p. 72.
Ulvacées Lamouroux, 1813, p. 275.

Most of the members of this family are marine, but some grow in brackish or fresh water. Plants are multicellular and parenchymatous, tubular, membranous, or a biseriate filament; attached or free-floating. Tubular forms with a monostromatic wall; membranous forms with either a monostromatic or distromatic flat blade. The thallus may be simple, lobed, or branched; attached by a basal holdfast composed of rhizoidal cells.

Cells cubical, uninucleate, usually with one large laminate or cup-shaped parietal chloroplast and one or more pyrenoids.

Vegetative reproduction occurs by fragmentation; reproduction also occurs by motile (zoospores) or non-motile (aplanospores) mitospores and motile meiospores (zoospores). The zoospores are biflagellate or quadriflagellate, with flagella of equal length, and from four to thirty-two are produced in the sporangium. The mitospores are liberated through a pore in the wall of the sporangium which is a modified vegetative cell.

Sexual reproduction is isogamous or anisogamous; gametes biflagellate with flagella of equal length; the gametes are liberated from the gametangium, which is a modified vegetative cell, through a pore in the wall; up to 64 gametes may be produced in the gametangium. Plants may be bisexual or unisexual, but usually the latter.

In certain forms there is an alternation of isomorphic generations in which the two (or three in the case of unisexual species) individuals are morphologically similar and cytologically different. In other instances the plant is haploid, with the diploid phase represented only by the zygote. In the former type the zygote develops immediately into a multicellular diploid thallus (sporophyte) but in the latter, after enlarging and an apparent period of dormancy, the zygote germinates and gives rise to as many as 64 quadriflagellate meiospores (zoospores). An alternation of heteromorphic generations has also been reported where the diploid zoospore-producing plant (which in some species is represented only by a diploid resting zygote) alternates with a diminutive but multicellular prostrate gamete-producing thallus.

KEY TO THE GENERA OF ULVACEAE

1. Thallus a distromatic membrane at maturity with the two cell layers generally in contact throughout .... ULVA, p. 57
1. Thallus not distromatic at maturity 2
   2. Thallus biseriate at maturity .... PERCURSARIA, p. 63
   2. Thallus not biseriate at maturity 3
3. Thallus a monostromatic membrane at maturity (saccate when young) .... MONOSTROMA, p. 33
3. Thallus not a monostromatic membrane at maturity 4
   4. Thallus with several narrow, unbranched, tubular, erect branches arising from a common basal parenchymatous disc; wall of tube one cell in thickness .... BLIDINGIA, p. 41
   4. Thallus at maturity a hollow membranous tube, attached by a pulvinate holdfast of rhizoidal cells; wall of tube one cell in thickness .... ENTEROMORPHA, p. 44

MONOSTROMA Thuret, 1854*a*, p. 29.

Thallus saccate when young with the wall one cell thick; sac later splitting longitudinally to form a broad, flattened monostromatic thallus; attached to the substratum by a pulvinate holdfast of rhizoidal cells which is initiated as a parenchymatous disc; epiphytic in some species, in others becoming free-floating. In most species the thallus begins as a small parenchymatous disc, but a uniseriate filamentous origin, similar to that encountered in *Enteromorpha*, is also known.

The cells are uninucleate; usually a single laminate chloroplast with one to several pyrenoids is present in each cell, but at least one species may possess two chloroplasts in each cell.

Vegetative reproduction occurs by fragmentation of the thallus. Some species apparently do not reproduce sexually but produce only biflagellate or quadriflagellate mitospores (neutral spores of Bliding, 1933, as in *Enteromorpha*).

Sexual reproduction occurs in some species; the gametes are biflagellate and isogamous or anisogamous and after fusion may result in an apparently dormant zygote; meiosis occurs on germination of this zygote and results in quadriflagellate meiospores (zoospores). The plants are usually unisexual. A type of alternation of heteromorphic generations has also been reported in *Monostroma* where the conventional monostromatic zoospore-producing (probably meiospores) thallus alternates with a diminutive but multicellular prostrate gamete-producing thallus. An alternation of isomorphic generations has also been reported in a unisexual species with the haploid gametophytes reproducing by anisogamous biflagellate gametes and the diploid sporophyte reproducing by quadriflagellate zoospores (meiospores). Parthenogenetic development of gametes has been recorded in some species. In some species motile cells are released through a distinct pore; in others there is a general breakdown of the cell wall preceding liberation of gametes or zoospores.

Although culture studies are as yet incomplete for the local plant of *Monostroma zostericola*, quadriflagellate zoospores have been obtained from the conventional monostromatic thallus of this species. These germinate and begin a phase of development comparable to the quadriflagellate zoospores reported from zygote germination. This suggests that meiospores (or mitospores which might be produced as an accessory method of reproduction) may occur in some species, and there may yet be found other species having an alternation of isomorphic generations, as in *Ulva*. Further culture and cytological work is needed to clarify these problems. On the basis of the present ontogenetic data available from culture studies, particularly of *Monostroma* but also of *Blidingia*, *Enteromorpha*, *Ulva*, and *Percursaria*, there is little justification for recognizing a separate family Monostromaceae (Kunieda, 1934, p. 106; Suneson, 1947, p. 245; Parke and Dixon, 1964, p. 531) to receive species of the genus *Monostroma* or for retaining the Ulvales as an order distinct from the Ulotrichales. Species having the type of alternation of generations where meiosis occurs on germination of the zygote, have been referred by Gayral (1964) to a separate genus, *Ulvopsis*. Kornmann (1965) places *Monostroma* in the family Monostromaceae in the order Ulotrichales.

Morphology and Reproduction:

Thuret, 1854*a*, p. 25–29.
DeToni, 1889, p. 98.
Carter, 1926, p. 665–689, pl. 23, figs. 28–71.
Printz, 1927, p. 175, fig. 126.
Hamel, 1928, p. 142–149, figs. 43–45.
Miyake and Kunieda, 1931, p. 342–348, figs. 1–29.
Kunieda, 1934, p. 103–106, figs. 1–12.
Bliding, 1935, p. 60–62, fig. 3.
Moewus, 1938, p. 364–370, figs. 1, 2; 1940, p. 225–238, figs. 1–18.
Yamada and Saito, 1938, p. 43–49, figs. 9–12, pl. 16.
Yamada and Kanda, 1941, p. 217–221, figs. 1–4, pls. 49, 50.
Suneson, 1947, p. 233–246, figs. 1, 2.

Schreiber, 1942, p. 414–417, fig. 1, table 1.
Arasaki, 1946, p. 283–285, fig. 2.
Shihira, 1958, p. 379–385.
Yamada and Tatewaki, 1959, p. 438; 1965, p. 105–117, figs. 1–7, pls. I–III.
Papenfuss, 1960, p. 309–311.
Iwamoto, 1960, p. 91–101, figs. 1–5, pl. I–IV.
Gayral, 1961, p. 1642–1644, figs. 1–8; 1962, p. 53–59, pls. 1, 2, figs. 1–12; 1964, p. 2149–2152.
Segi and Kida, 1961, p. 223–226, figs. 1–6.
Chihara, 1962, p. 44, 45.
Noda, 1962, p. 73–86, figs. 1–8.
Kornmann, 1962*a*, p. 37–39; 1962*b*, p. 195–202, figs. 1–5; 1963*b*, p. 60–68, fig. 1; 1964*b*, p. 13–21, figs. 1–5; 1965, p.163–172, figs. 2, 4, 5.
Kornmann and Sahling, 1962, p. 302–320, figs. 1–13.
Tatewaki, 1963, p. 381–387, figs. 1–5.
Parke and Dixon, 1964, p. 531.

Several species are recorded for this area, although these entities have been little studied as yet in the living condition in culture to clarify life-history and reproductive characteristics. A more complete study of these entities is necessary along such lines before the morphological and anatomical criteria now used to distinguish taxa can be adequately assessed. The fact that the size of cells may vary considerably on the same individual depending on whether measurements are made near the base or distally, as well as with age, makes this characteristic alone of somewhat dubious value. Until more of the local species have been studied more intensively to determine specific details concerning their life histories and reproduction, it is premature to attempt referring these species to three separate genera, *Monostroma, Ulvaria,* and *Ulvopsis,* as Gayral (1964) does. It is also questionable whether such emphasis on the type of life history in itself is a valid basis for distinguishing genera in this complex of species.

Key to the Species of Monostroma

1. Thallus 7–15 μ in thickness, cells 5 μ or less in diameter in surface view, 5–8 μ high in sectional view .... *M. zostericola,* p. 40
1. Thallus more than 15 μ in thickness, cells more than 5 μ in diameter in surface view 2
    2. Thallus dull green, darkening with age and becoming olive brown to almost black on drying .... *M. fuscum,* p. 36
    2. Thallus bright green, pale green, or yellowish green, not becoming dark brown to black on drying 3
3. Cells oblong in surface view, close-set, acutely angular, 5–10 μ in diameter and in more or less distinct longitudinal rows; thallus large (to 55 cm high) .... *M. fractum,* p. 36
3. Cells more or less isodiametric in surface view 4
    4. Thallus 20–25 μ in thickness; cells in regular groups of 2–6, rounded at the corners in surface view; in sectional view oval .... *M. oxyspermum,* p. 39
    4. Thallus 25–45 μ in thickness; cells not in regular groups, close-set and angular in surface view; in sectional view more or less rectangular but with corners rounded .... *M. arcticum,* p. 35

Monostroma arcticum Wittrock, 1866, p. 44.
Pl. 18, fig. F; pl. 19, fig. B.

Thallus pale green, up to 15 cm high and 10 cm wide, saccate when young, later splitting into a few broad lobes. Sometimes the saccate form persists until the plant is several centimetres high. Thallus 25–45 μ in thickness. Cells in surface view (7–) 10–18 μ in diameter, angular, close-set and irregularly arranged; in sectional view 10–25 μ high, more or less rectangular with rounded corners; a single chloroplast with one or two pyrenoids.

Terminally biflagellate gametes (16 to 32 per gametangium) with a single chloroplast, eyespot, and pyrenoid have been observed, but the life history and reproduction are still incompletely known.

References:

Wittrock, 1866, p. 44, pl. 2, fig. 8, a–g.
Agardh, 1883, p. 106.
Kjellman, 1883*a*, p. 299.
DeToni, 1889, p. 105.
Rosenvinge, 1893, p. 949, fig. 51; 1894, p. 152, fig. 51 (as *M. grevillei* var. *arctica*).
Collins, Holden and Setchell, 1902, XIX (No. 910).
Setchell and Gardner, 1903, p. 208; 1920*a*, p. 238.
Collins, 1903, p. 13, pl. 41, figs. 6, 7; 1909*a*, p. 210.
Tokida, 1954, p. 61, pls. V, figs. 14–17; VII, figs. 1–7.
Noda, 1962, p. 83, fig. 1.
Kornmann and Sahling, 1962, p. 305–307, figs. 1–4.

Habitat. On stones, shells, and epiphytic on other algae, including *Odonthalia floccosa* and *Cystoseira geminata,* in the middle and lower intertidal zones.

Type Locality. Maasö, West Finmark, Norway.

Pacific Coast Distribution. Amaknak Island, Alaska, to Northern Washington.

Monostroma fractum Jao, 1937, p. 102.
Pl. 18, figs. D, E; pl. 19, fig. A.

Thallus up to 7 cm wide and 55 cm long, yellowish green with an undulate margin, usually longitudinally split at maturity into several segments. Thallus 21–24 μ thick; cells in surface view oblong, acutely angular, 5–10 μ in diameter and 10–30 μ long, close-set and in more or less distinct longitudinal rows; cells in cross section 5–10 μ in diameter and 12–14 μ high, ovoid to rectangular. Chloroplast fills the whole cell and usually has one, but sometimes two, pyrenoids.

Life history and reproduction in this species are still unknown.

References:

Jao, 1937, p. 102, pl. XIII, figs. 8–10.
Scagel, 1957, p. 34.

Habitat. Floating in shallow water on mud flats in the intertidal zone.

Type Locality. Turn Island, San Juan Island, Washington (S, isotype of Jao's 1095).

Pacific Coast Distribution. Northern Washington.

Monostroma fuscum (Postels and Ruprecht) Wittrock, 1866, p. 53.

Thallus at first a hollow sac, soon splitting to form a monostromatic blade; dull green in colour, becoming darker and in some forms olive brown to almost black on drying. Usually only one chloroplast, but two, one at each end of the cell, have been reported; one to six or more pyrenoids.

Quadriflagellate zoospores and biflagellate gametes (with 32 gametes in the gametangium) have both been observed, but the life history and reproduction are still incompletely known. The data available suggest that there is an alternation of isomorphic generations in this species, but not all varieties have been studied in detail. Some authors consider that this species, and others having an alternation of isomorphic generations, should be referred to a distinct genus, and have adopted the generic name *Ulvaria* for such species.

Three varieties of this species have been recorded for this area (*M. fuscum* var. *blyttii, M. fuscum* var. *fuscum* and *M. fuscum* var. *splendens*). The chief basis for distinguishing these entities has been cell size and degree of splitting of thallus, although representatives of the species have not been sufficiently studied in the living condition to determine the validity of these distinctions. Although these forms may eventually be found to be ecological variants of one variable species, for the present they are considered as distinct varieties. They have been regarded even as distinct species rather than varieties by some authors. The following key, based upon Setchell and Gardner's (1920*a*) concept of this species, is followed, and the criteria used to separate the varieties are indicated in it.

Morphology and Reproduction:

Postels and Ruprecht, 1840, p. 21 (as *Ulva fusca*).
Wittrock, 1866, p. 53, pl. 4, fig. 13, a–f.
Collins, 1909*a*, p. 213.
Printz, 1927, p. 176, fig. 126.
Tatewaki, 1963, p. 381–387, figs. 1–5.
Gayral, 1964, p. 2149–2152 (as *Ulvaria fusca*).

KEY TO THE VARIETIES OF MONOSTROMA FUSCUM

1. Thallus 17–45 μ in thickness .... *M. fuscum* var. *fuscum*, p. 38
1. Thallus 50–58 μ in thickness .... *M. fuscum* var. *splendens*, p. 39
1. Thallus 60–72 μ in thickness .... *M. fuscum* var. *blyttii*, p. 37

Monostroma fuscum var. **blyttii** (Areschoug) Collins, 1903, p. 12.
Pl. 19, fig. E; pl. 21, fig. A.

Thallus at first saccate, soon splitting irregularly and eventually forming a broad, irregular, lobed, dark green monostromatic blade up to 30 cm tall and 40 cm broad; turning dark olive brown to black on drying. Thallus 60–72 μ thick; cells quadrate, 15–20 μ in diameter in surface view, closely set, angular but rounded at the corners; in sectional view cells elongate, 55–60 μ tall and 15–20 μ broad. A single chloroplast (two have been reported) with one to four pyrenoids. Terminally biflagellate gametes (32 per gametangium) and quadriflagellate zoospores have been observed but the life history and reproduction are still incompletely known; there is probably an alternation of isomorphic generations.

References:

Areschoug, *in* Fries, 1846, p. 129 (as *Ulva blyttii*).
Areschoug, 1850, p. 412, pl. 1, fig. G (as *Ulva blyttii*).
Wittrock, 1866, p. 49, pl. 3, fig. 11, a, b (as *M. blyttii*).

Agardh, 1883, p. 113, pl. 3, figs. 93, 94 (as *M. blyttii*).
Kjellman, 1883*a*, p. 299 (as *M. blyttii*).
DeToni, 1889, p. 108 (as *M. blyttii*).
Hariot, 1889*b*, p. 155 (as *M. blyttii*).
Collins, 1903, p. 12, pl. 41, figs. 2, 3; 1909*a*, p. 211; 1913, p. 102.
Setchell and Gardner, 1920*a*, p. 243.
Newton, 1931, p. 74, fig. 54.
Taylor, 1937, p. 72; 1957, p. 70.
Scagel, 1957, p. 34.

Habitat. On pebbles and in tide pools in the lower intertidal zone.

Type Locality. Coast of Finmark, Norway (*Ulva blyttii*).

Pacific Coast Distribution. Southern British Columbia to Northern Washington.

Monostroma fuscum (Postels and Ruprecht) Wittrock var. **fuscum**, 1866, p. 53.

Pl. 19, fig. D; pl. 20, fig. A.

Thallus at first a hollow sac, soon splitting to form a monostromatic blade, 10–25 cm high, 15–18 cm wide, dull green in colour, more or less lobed; (17–) 20–35 (–45) μ in thickness; mature thallus frequently dissected into deep lobes. The cells are quadrate in surface view, close-set, angular but rounded at the corners, (5–) 7–15 (–20) μ in diameter; in sectional view cells are 17–35 μ high and occupy almost the full thickness of the thallus. Chloroplast a parietal laminate plate with one to six (to ten) pyrenoids.

Both biflagellate gametes and quadriflagellate zoospores have been observed but the life history and reproduction are still incompletely known. There is probably an alternation of isomorphic generations.

References:

Postels and Ruprecht, 1840, p. 21 (as *Ulva fusca*).
Kützing, 1849, p. 475 (as *Ulva fusca*).
Areschoug, 1850, p. 413, pl. 1, fig. H. (as *Ulva sordida*).
Wittrock, 1866, p. 53, pl. 4, fig. 13, a–f (as *M. fuscum*).
Hauck, 1885, p. 425.
DeToni, 1889, p. 109 (as *M. fuscum*).
Setchell and Gardner, 1903, p. 208; 1920*a*, p. 242 (as *M. fuscum*).
Collins, 1903, p. 11; 1909*a*, p. 213, pl. VII, fig. 72 (as *M. fuscum*.)
Oltmanns, 1904, p. 206, fig. 132.
Hamel, 1928, p. 145, figs. 44A, 45D–F.
Newton, 1931, p. 74.
Levring, 1937, p. 18.
Kylin, 1949, p. 14.
Tokida, 1954, p. 64, pl. VI, figs. 4, 10, 11; pl. XI, fig. A (as *M. fuscum* var. *typicum*).
Scagel, 1957, p. 35.

Habitat. On stones and epiphytic on other algae in the middle intertidal zone or floating in brackish water.

Type Locality. West coast of North America (probably from Aleutian Islands, Alaska) (S, *Ulva fusca*).

Pacific Coast Distribution. Bering Sea and Aleutian Islands, Alaska (Trapper's Cove, Adak Island (UBC 10031;8115); Finger Bay, Adak Island (UBC 8116;8117)), to Northern Washington.

Monostroma fuscum var. **splendens** (Ruprecht) Rosenvinge, 1893, p. 940.
Pl. 19, fig. C; pl. 20, fig. B.

Thallus at first a hollow sac, soon splitting to form a monostromatic blade, 10–15 cm high, up to 10 cm broad, deep glossy green, more or less deeply lobed at maturity; 50–58 μ in thickness. Cells 15–20 μ in diameter in surface view, quadrate, close-set but with rounded corners; in sectional view cells 40 μ in height and 20–25 μ in breadth. Chloroplast a parietal laminate plate with three or four pyrenoids.

Both biflagellate gametes and quadriflagellate zoospores have been observed, and an alternation of isomorphic generations has been reported.

References:

Ruprecht, 1851, p. 410 (as *Ulva splendens* and *Ulvaria splendens*).
Wittrock, 1866, p. 50, pl. 3, fig. 12 (as *M. splendens*).
Agardh, 1883, p. 112, pl. 3, figs. 91, 92 (as *M. splendens*).
Kjellman, 1889, p. 54 (as *M. splendens*).
DeToni, 1889, p. 107 (as *M. splendens*).
Rosenvinge, 1893, p. 940.
Setchell, 1899, p. 591 (as *M. splendens*).
Collins, Holden and Setchell, 1902, XIX (No. 911).
Setchell and Gardner, 1903, p. 209; 1920*a*, p. 242.
Collins, 1903, p. 12; 1909*a*, p. 213; 1913, p. 102.
Tokida, 1954, p. 65, pl. III, figs. 5, 6, pl. VI, figs. 5, 9, 12, 13, pl. XI, fig. B.
Scagel, 1957, p. 35.
Papenfuss, 1960, p. 310.
Tatewaki, 1963, p. 381–387, figs. 1–5.

Habitat. On stones in the middle intertidal zone.

Type Locality. Bering Sea (probably from Aleutian Islands, Alaska) (LD 13315, S, *Ulva splendens*).

Pacific Coast Distribution. St. Paul Island, Alaska, to Southern British Columbia.

Monostroma oxyspermum (Kützing) Doty, 1947, p. 12.
Pl. 20, fig. C; pl. 21, fig. B.

Thallus at first saccate, sometimes persisting as a sac until several centimetres high, soon becoming split into an irregularly lobed membrane, up to 10 (–30) cm broad and 20 (–40) cm high at maturity; thallus 20–25 (–30) μ thick. Cells 7–10 μ in diameter in surface view, rounded and in regular groups of two to four to six; in sectional view cells are ovoid to elliptical, 10–15 μ high and 7–10 μ in diameter; a single chloroplast with usually one pyrenoid in each cell.

Terminally biflagellate gametes (16–32 per gametangium) have been observed, but the life history and reproduction are still incompletely known.

References:

Kützing, 1843, p. 296, pl. 20, fig. 4 (as *Ulva latissima*), p. 296 (as *U. oxysperma*); 1845, p. 244 (as *Ulva oxycocca* and *U. latissima*); 1849, p. 474 (as *Ulva oxycocca* and *U. latissima*); 1856, p. 6, pl. 13, fig. 1 (as *Ulva oxycocca*), fig. 2 (as *U. quaternaria*), p. 7, pl. 14 (as *U. latissima*).
Thuret, 1854*a*, p. 29 (as *M. oxycoccum*); 1854*b*, p. 388 (as *M. orbiculatum*).
Wittrock, 1866, p. 32, pl. 1, fig. 3 (as *M. oxycoccum*), p. 33, pl. 1, fig. 4

(as *M. latissimum*), p. 37, pl. I, fig. 5 (as *M. quaternarium*), p. 39, pl. II, fig. 6 (as *M. orbiculatum*).
Agardh, 1883, p. 98 (as *M. quaternarium*), p. 99 (as *M. latissimum*).
Kjellman, 1883*a*, p. 294 (as *M. latissimum*).
DeToni, 1889, p. 100 (as *M. quaternarium*), p. 101 (as *M. oxycoccum*), p. 102 (as *M. latissimum*).
Collins, Holden and Setchell, 1899, XII (No. 567) (as *M. quaternarium*); 1912, XXXVIII (No. 1859) (as *M. latissimum*).
Collins, 1903, p. 16, pl. 41, figs. 14, 15 (as *M. crepidinum*), pl. 41, figs. 18, 19 (as *M. latissimum*), p. 17, pl. 41, figs. 16, 17 (as *M. quaternarium*); 1909*a*, p. 211 (as *M. latissimum*), p. 212 (as *M. quaternarium*); 1913, p. 102 (as *M. latissimum*).
Setchell and Gardner, 1903, p. 207 (as *M. latissimum* and *M. quaternarium*); 1920*a*, p. 240 (as *M. quaternarium*), p. 241 (as *M. latissimum*), p. 242 (as *M. orbiculatum*).
Hamel, 1928, p. 146 (as *M. oxycoccum*).
Taylor, 1937, p. 71, pl. 4, figs. 1–3 (as *M. latissimum* and *M. wittrockii*), p. 72 (as *M. orbiculatum* var. *varium*), p. 73 (as *M. crepidinum*); 1957, p. 72, pl. 4, figs. 1–3.
Doty, 1947, p. 12, pl. 2, figs. 13–15.
Kylin, 1949, p. 14 (as *M. latissimum*).
Chapman, 1956, p. 379, fig. 19 (as *M. latissimum*).
Scagel, 1957, p. 35.
Papenfuss, 1960, p. 315.
Kornmann, 1964*b*, p. 13–21, figs. 1–5.

Habitat. On stones and shells (or floating) in the lower intertidal zone.

Type Locality. Baltic Sea.

Pacific Coast Distribution. Southern British Columbia to Southern California.

Monostroma zostericola Tilden, 1900, IV (No. 388).
Pl. 18, figs. A–C.

Thallus epiphytic along the leaf margins of *Zostera* and *Phyllospadix;* saccate when young, soon splitting to form a flat monostromatic blade; sessile; 2–3.5 (–5) cm high, irregular in outline; frequently ragged along the margins; 1–2 cm broad; usually cuneate at the base at maturity. Thallus 7–10 (–15) μ in thickness; cells in cross sectional view quadrate to rectangular, 5–8 μ tall. Cells in surface view angular, 2.5–5 μ in diameter, in more or less distinct longitudinal and transverse series.

Chloroplast laminate and parietal with one or two pyrenoids.

Zoospores (probably mitospores) are anteriorally quadriflagellate with a posterior laminate chloroplast, one pyrenoid; no eyespot has been detected; from eight to sixteen zoospores are produced in the sporangium. Zoospores germinate (*see* p. 41) to form a simple filament which soon branches and, following an apparently parenchymatous phase of development, results in a disc; the centre of the disc becomes multilayered and eventually gives rise to an erect hemispherical swelling, at first solid, but subsequently becoming hollow and producing a globose, juvenile thallus with a monostromatic wall. This saccate stage soon becomes split longitudinally to form the mature, flat, blade-like thallus.

Yamada and Tatewaki (1959, 1965) have reported a sexual stage in an epiphytic species in Japan referred to *Monostroma zostericola*; this is a diminutive discoid stage which is very similar to the early stage of development of the zoospore-producing plant. The biflagellate gametes are produced in surface cells of the central, multilayered portion of the disc. The local species from the type locality has not as yet been fully studied in culture and, although a similar sexual stage may be found, it should be noted that certain features about the Japanese plant referred to *M. zostericola* suggest that these may not be the same species: the size of the vegetative cells and also the size of the zoospores seem to be consistently different in the two entities.

References:

Tilden, 1900, IV (No. 388).
Setchell and Gardner, 1903, p. 209 (as *M. leptodermum*); 1920*a*, p. 238, pl. 14, figs. 12, 13.
Collins, 1909*a*, p. 213 (as *M. leptodermum*); 1913, p. 103 (as *M. leptodermum*).
Yamada and Kanda, 1941, p. 217, figs. 1–4, pls. 49, 50.
Smith, 1944, p. 43.
Sanborn and Doty, 1947, p. 24.
Doty, 1947, p. 11, pl. 2, figs. 4, 5.
Tokida, 1954, p. 59, pl. VI, figs. 1–3.
Scagel, 1957, p. 36.
Yamada and Tatewaki, 1959, p. 438; 1965, p. 105–117, figs. 1–7, pls. I–III.
Noda, 1962, p. 73, fig. 1.
Tatewaki, 1963, p. 386.

Habitat. Epiphytic on leaves of *Zostera* and *Phyllospadix*.

Type Locality. San Juan Island, Washington.

Pacific Coast Distribution. West coast of Vancouver Island (Garden Island, entrance to Kyuquot Sound, UBC 10496) to Monterey, California.

BLIDINGIA, Kylin, 1947, p. 8.

Mature plants tubular, branched or unbranched, gregarious, with several thalli arising from a common, cushion-like, parenchymatous, polystromatic base. The erect thallus does not arise from the cushion-like base as a uniseriate filament. It arises as a result of an extensive upheaval of cells from the base, and this erect portion subsequently becomes hollow and tubular. Cells angular, irregularly arranged (in tall forms tending to be arranged in irregular longitudinal rows in the narrow regions) with a single parietal chloroplast and one pyrenoid.

Reproduction by quadriflagellate zoospores (probably mitospores) which lack an eyespot. On germination, zoospores develop into filamentous germlings; these pass through an initial parenchymatous phase of development resulting in a cushion-like base from which numerous erect tubular thalli are later initiated. Sexual reproduction unknown.

Morphology and Reproduction:

Setchell and Gardner, 1920*a*, p. 249, 250, pl. 16, fig. 1 (as *Enteromorpha minima* and *E. micrococca*).
Bliding, 1938, p. 83–90, figs. 1–6 (as *Enteromorpha minima*); 1963, p. 23–40, figs. 7–15.
Sjöstedt, 1939, p. 18, fig. 1 (as *Enteromorpha minima*), p. 38, figs. 8, 9 (as *E. nana*).

Yamada and Kanda, 1941, p. 221–225, figs. 5–8 (as *Enteromorpha nana* var. *minima*).
Smith, 1944, p. 50, pl. 5, fig. 8 (as *Enteromorpha minima* and *E. micrococca*).
Doty, 1947, p. 17, 18, pl. 3, figs. 1–4 (as *Enteromorpha minima*).
Kylin, 1947, p. 8; 1949, p. 30, figs. 30, 31.
Dangeard, 1955, p. 1539–1542, figs. A, B; 1958*a*, p. 347–351, figs. A–K; 1958*b*, p. 58, 59, fig. 26; 1964, p. 174.
Papenfuss, 1960, p. 312.

One species with two varieties is described from the area.

Blidingia minima (Nägeli) Kylin, 1947, p. 8.

Plants tubular, simple or branched, gregarious with several tubular thalli arising from a common cushion-like base; gradually increasing in diameter distally. In sectional view the thallus is 8–10 (–18) μ thick and cells are (3–) 5–6 μ wide and (5–) 7–10 (–15) μ high; the cells are more or less equidistant from the inner and outer surfaces. In surface view cells are angular with rounded corners, 5–7 μ in diameter, irregularly arranged, with a single parietal chloroplast and one pyrenoid.

Key to the Varieties of Blidingia minima

1. Thallus short, usually less than 5 cm high, generally unbranched and characteristically forming a dense green carpet high in the intertidal zone .... *B. minima* var. *minima*, p. 42
1. Thallus long, frequently up to 0.5 m, generally branched, usually in dense mats on mud flats or in brackish areas and lagoons .... *B. minima* var. *subsalsa*, p. 43

Blidingia minima (Nägeli) Kylin var. **minima**, Kylin, 1947, p. 8.
Pl. 21, figs. C–E.

Plants tubular, yellowish green to dark green, 1–5 (–7) cm high, 1–3 (–5) mm diameter at the distal end, usually unbranched (occasionally with short proliferous branches), gregarious with several tubular plants arising from a common, cushion-like base, gradually decreasing in diameter proximally. Thallus 8–10 (–18) μ thick. Cells in surface view angular with rounded corners, 5–7 μ in diameter, irregularly arranged, with a single parietal chloroplast and one pyrenoid; cells in sectional view centrally placed or slightly nearer to the outer surface, (3–) 5–6 μ wide and (5–) 7–10 (–15) μ high.

References:

Nägeli, *in* Kützing, 1849, p. 482 (as *Enteromorpha minima*).
Kützing, 1856, p. 16, pl. 43, fig. 3, i–m (as *Enteromorpha minima*), p. 11, pl. 30, fig. 2 (as *E. micrococca*).
Ahlner, 1877, p. 48, fig. 8, a, b (as *Enteromorpha minima*), p. 46, fig. 7, a, b (as *E. micrococca*).
Agardh, 1883, p. 123 (as *Enteromorpha micrococca*), p. 135 (as *E. minima*).
Hauck, 1885, p. 432 (as *Enteromorpha minima* and *E. micrococca*).
DeToni, 1889, p. 125 (as *Enteromorpha minima*), p. 119 (as *E. micrococca*).
Collins, Holden and Setchell, 1895, II (No. 66) (as *Enteromorpha micrococca*); 1898, X (No. 468) (as *E. minima*); 1915, XLI (No. 2005) (as *E. minima*).
Saunders, 1901, p. 411 (as *Enteromorpha micrococca*).
Collins, 1903, p. 20, pl. 42, figs. 1, 2 (as *Enteromorpha micrococca*), p. 24, pl. 42, figs. 9, 10 (as *E. minima*); 1909*a*, p. 204 (as *E. micrococca*), p. 201 (as *E. minima*); 1913, p. 102 (as *E. minima* and *E. micrococca*).

Setchell and Gardner, 1903, p. 213 (as *Enteromorpha micrococca*); 1920*a*, p. 249 (as *E. micrococca*), p. 250 (as *E. minima*).
Newton, 1931, p. 71 (as *Enteromorpha minima*).
Levring, 1935, p. 7 (as *Enteromorpha micrococca*); 1937, p. 19 (as *E. micrococca*).
Taylor, 1937, p. 66 (as *Enteromorpha minima*); 1957, p. 67 (as *E. minima* and *E. micrococca*).
Bliding, 1938, p. 83, figs. 1–6; 1963, p. 23–27, fig. 7.
Sjöstedt, 1939, p. 18, fig. 1 (as *Enteromorpha minima*); p. 38, fig. 7 (as *E. nana* var. *minima*).
Yamada and Kanda, 1941, p. 221, figs. 5–8 (as *Enteromorpha nana* var. *minima*).
Smith, 1944, p. 50, pl. 5, fig. 8 (as *Enteromorpha minima* and *E. micrococca*).
Sanborn and Doty, 1947, p. 24 (as *E. micrococca*).
Doty, 1947, p. 17, pl. 3, figs. 1–4 (as *Enteromorpha minima*); 1948, p. 257 (as *B. minima*).
Kylin, 1947, p. 8; 1949, p. 30, figs. 30, 31 (as *B. minima*).
Waern, 1952, p. 39.
Tokida, 1954, p. 51 (as *Enteromorpha nana* var. *minima*).
Chapman, 1956, p. 413, fig. 59, a–c (as *Enteromorpha nana* var. *minima*).
Scagel, 1957, p. 36.
Dangeard, 1958*b*, p. 58, 59, fig. 26; 1958*d*, p. 144, pl. 1; 1964, p. 174.
Levring, 1960, p. 9.

Habitat. On rocks and old wood in the upper intertidal zone, characteristically forming a dense green carpet.

Type Locality. Helgoland, Germany (L.150/No. 1).

Pacific Coast Distribution. Dutch Harbor, Alaska, to Mexico and in Chile.

Blidingia minima var. **subsalsa** (Kjellman) Scagel, 1957, p. 37.
Pl. 22, figs. A–D.

Plants tubular, often much contorted, yellowish green, up to 0.5 m high, 1–2 mm diameter; numerous branches usually present, with broad bases and tapering distally to a point. Thallus 10–12 μ thick. Cells in surface view angular, 5–7 μ in diameter, with rounded corners, irregularly arranged, with a single parietal chloroplast and one pyrenoid; cells in sectional view 6–9 μ high and 5–7 μ in diameter, centrally located or slightly nearer to the outer surface.

References:
Kjellman, 1883*a*, p. 292, pl. 31, figs. 1–3 (as *Enteromorpha micrococca* f. *subsalsa*).
DeToni, 1889, p. 120 (as *Enteromorpha micrococca* f. *subsalsa*).
Setchell and Gardner, 1903, p. 211 (as *Enteromorpha micrococca* f. *subsalsa*), p. 213 (in part as *E. minima*); 1920*a*, p. 249, pl. 16, fig. 1 (as *Enteromorpha micrococca* f. *subsalsa*).
Collins, Holden and Setchell, 1903, XXII (No. 1068) (as *Enteromorpha micrococca* f. *subsalsa*).
Collins, 1903, p. 20; 1909*a*, p. 204; 1913, p. 102 (as *Enteromorpha micrococca* f. *subsalsa*).
Taylor, 1937, p. 67; 1957, p. 67 (as *Enteromorpha minima* f. *glacialis*).
Sjöstedt, 1939, p. 49, fig. 9 (as *Enteromorpha minima* var. *glacialis*, *E. micrococca* f. *subsalsa*, and *E. nana* var. *subsalsa*).
Doty, 1947, p. 17 (as *Enteromorpha minima* var. *subsalsa*).

Tokida, 1954, p. 52 (as *Enteromorpha nana* var. *subsalsa*).
Scagel, 1957, p. 37.
Bliding, 1963, p. 27–30, figs. 8, 9 (as *B. minima* var. *ramifera*).

Habitat. On rocks in the intertidal zone and above the intertidal zone on dripping rocks; common in lagoons and on mud flats.

Type Locality. In Arctic Ocean, probably at Pitelkay, Siberia (S).

Pacific Coast Distribution. Skagway, Alaska, to Oregon.

ENTEROMORPHA Link, *in* C. G. Nees, 1820, p. 5, *nom. cons.*

Thallus hollow and tubular, except near the base; sometimes markedly flattened; wall of the tube one cell in thickness; branched or unbranched; solitary or aggregated in tufts or dense stands; sometimes free-floating. Attached by an extensive basal rhizoidal system of non-septate filaments. Perennial from the base in some species. The erect thallus initially arises usually as a uniseriate filament. After subsequent divisions the multiseriate thallus becomes hollow and tubular. Dangeard (1959) and Dangeard and Parriaud (1960) have described an initial disc development in certain species.

The cells are uninucleate and embedded in a homogeneous mucilaginous matrix; a single laminate or cup-shaped chloroplast with one to several pyrenoids.

Vegetative reproduction by fragmentation occurs; motile quadriflagellate (zoospores) and non-motile (aplanospores) mitospores and quadriflagellate meiospores are produced; the flagella are equal in length. The spores are produced in undifferentiated cells with four, eight, or sixteen arising from each cell through a pore in the surface of the cell. Sexual reproduction is isogamous or anisogamous by terminally biflagellate gametes; flagella are equal in length; gametes are produced in undifferentiated gametangia, eight, sixteen, or thirty-two to the cell, and liberated through a pore in the surface of the cell wall. The plants may be bisexual or unisexual. In some species only zoospores (probably mitospores) are produced.

An alternation of isomorphic generations occurs in some species, but in others a sexual generation is apparently lacking (*see also* discussion on p. 23 concerning *Collinsiella*).

Several species and varieties are recorded for this area, but these have been little studied in the living condition in culture or in the field to clarify life-history and reproductive characteristics. The need for a thorough study along these lines to establish the degree of variability in these entities and the extent to which morphological and anatomical criteria can be used to distinguish taxa has already been demonstrated in some species (Bliding, 1933, 1935, 1938, 1939, 1944, 1948, 1955; Kylin, 1930, 1947; Arasaki and Shihira, 1959). Until more of this type of study has been undertaken on the Pacific Coast species, the genus cannot be treated in a satisfactory way. The following treatment must, therefore, be considered as a very preliminary one. Except for a few clear-cut entities, many of the forms described and recorded for this area are likely only variants in extremely plastic taxa. The morphological criteria used to distinguish species and varieties are based largely upon those used by Setchell and Gardner (1920*a*), Doty (1947), and Bliding (loc. cit.).

Morphology and Reproduction:

Link, *in* Nees, 1820, p. 5.
Hartmann, 1929, p. 490–494.
Hamel, 1928, p. 149–167, figs. 46–51.
Kylin, 1930, p. 458–464, figs. 1–10; 1949, p. 19–29, figs. 12–29.
Miyake and Kunieda, 1931, p. 349–351, figs. 30–55.
Bliding, 1933, p. 233–256, figs. 1–18; 1938, p. 83–90, figs. 1–7; 1939, p. 134–144, figs. 1–7; 1944, p. 331–356, figs. 1–26; 1948, p. 123–136, figs. 1–10; 1955, p. 253–262, figs. 1–6; 1960, p. 172–184, figs. 1–11; 1963, p. 41–148, figs. 16–92.
Moewus, 1938, p. 374–435, figs. 5–40.
Yamada and Saito, 1938, p. 40, 41, figs. 6–8.
Sjöstedt, 1939, p. 15–62, figs. 1–11; 1940, p. 7–25, figs. 1–8.
Ramanthan, 1939, p. 375–398, figs. 1–74.
Arasaki, 1946, p. 281–283, fig. 1.
Silva, 1952, p. 294.
Waern, 1952, p. 31–39, figs. 14–17.
Dangeard, 1955, p. 1539–1542, figs. C–G; 1957*a*, p. 1589–1592; 1957*b*, p. 2454–2457, figs. A, B; 1959*a*, p. 889–892, figs. 1–29; 1959*b*, p. 177–181; 1960*a*, p. 103–114, figs. 1–4, pl. 1; 1964, p. 171–174.
Cauro, 1958, p. 89–141, pls. I, II.
Gayral, Dangeard and Cauro, 1958, p. 386–390, figs. A–M.
Burrows, 1959, p. 204–206.
Gayral, 1959, p. 85–100, pls. 2, 3; 1960*a*, p. 85–100, pls. 2, 3; 1961, p. 229–239, pls. 1–4.
Arasaki and Shihara, 1959, p. 92–100, figs. 1, 2.
Scagel, 1960, p. 969–983, figs. 1–48.
Papenfuss, 1960, p. 311.
Dangeard and Parriaud, 1960, p. 2972–2975, figs. 1, 2.
Comps, 1960*a*, p. 37–75, pls. 1–4; 1960*b*, p. 2067–2069, figs. A–D.
Lersten and Voth, 1960, p. 33–45, figs. 1–14.
Christie and Evans, 1962, p. 193, 194, fig. 1.
Noda, 1962, p. 76–86, figs. 4–7.
Parriaud, 1964, p. 127–132, pl. 1, fig. 1.
Hoek, 1964*b*, p. 33–38.

Key to the Species of Enteromorpha

1. Thallus unbranched, tubular near the base, becoming flat and broadening distally with two cell layers completely joined or remaining hollow only along the margins; in sectional view cells usually taller than broad .... *E. linza*, p. 52
1. Thallus tubular throughout, branched or unbranched, cylindrical or flattened distally 2
    2. Cells, except near the base or in young portions, not arranged in regular longitudinal rows 3
    2. Cells arranged in regular longitudinal rows throughout the thallus 4
3. Thallus tubular, usually unbranched and more or less cylindrical throughout; often much crisped and contorted or constricted; thallus usually over 20 μ thick with cells nearer the outer surface .... *E. intestinalis*, p. 49
3. Thallus tubular, usually branched, cylindrical near the base, but compressed and usually flattened and broad distally, with the two layers of cells sometimes imperfectly separated in the compressed region; thallus usually under 20 μ thick with cells more or less centrally located .... *E. compressa*, p. 47
    4. Thallus simple, or with occasional proliferous branches of two rows of cells; cells always in longitudinal series throughout and more or less in transverse rows .... *E. torta*, p. 55
    4. Thallus otherwise 5
5. Thallus much and repeatedly branched with tips of branches usually terminating in a uniseriate series of short cells .... *E. crinita*, p. 48
5. Thallus otherwise 6

6. Thallus large, up to several metres long, tubular or compressed distally, with abundant proliferous branches; branches simple or branched; cells in longitudinal series in youngest parts and branches, but less distinct in older parts .... *E. prolifera*, p. 54
6. Thallus otherwise 7
7. Cells usually less than 10 μ in diameter in surface view .... *E. marginata*, p. 54
7. Cells usually more than 10 μ in diameter in surface view 8
8. Thallus simple or with short proliferous branches; cells squarish, slightly elongated in sectional view; chloroplast filling outer end of cell .... *E. tubulosa*, p. 56
8. Thallus much branched in all directions, cells rectangular, longer than broad in sectional view, chloroplast small .... *E. clathrata*, p. 46

Enteromorpha clathrata (Roth) Greville, 1830, p. 181.
Pl. 22, figs. E, F; pl. 23, figs. A, B.

Thallus pale to deep green, up to 0.5 (–5) mm in diameter, filiform, cylindrical or compressed, up to 5 cm (–1 m) in height, profusely and repeatedly branched, especially from the base; branches tapering from base to apex, usually multiseriate at apex (rarely uniseriate); usually attached, but sometimes free-floating. Cells, except near the base of the plant, arranged in longitudinal rows, usually longer than broad—in surface view up to (8–) 28 μ wide and up to (13–) 30–50 μ long; usually with cells smaller and squarish in branches; chloroplast usually conspicuously smaller than cell and at the outer face of cell, with (1–) 2–5 (–12) small pyrenoids. In sectional view thallus is 18–30 μ thick, and the cells are 14–25 μ high and centrally located.

Reproduction occurs by motile quadriflagellate meiospores (zoospores) which are 4.3 by 9.8 μ, with an eyespot and usually two pyrenoids.

Sexual reproduction is anisogamous, and the gametes are anteriorally biflagellate with one pyrenoid and an eyespot; male gametes are 2.5 by 5.5 μ; female gametes are 2.8 by 6.3 μ; male and female gametes also develop parthenogenetically.

There is an alternation of isomorphic generations, and the plants are unisexual.

There is considerable variability in the branching habit and diameter of the thallus and branches, especially in the free-floating forms.

References:

Roth, 1806, p. 175 (as *Conferva clathrata*).
Agardh, 1817, p. 46 (as *Ulva clathrata*); 1822, p. 422 (as *U. clathrata*).
Lyngbye, 1819, p. 65, pl. 15C (as *Scytosiphon erectus*); p. 66, pl. 16A (as *S. clathratus*).
Greville, 1830, p. 181.
Kützing, 1843, p. 300; pl. 20, fig. 1 (as *E. plumosa*).
Harvey, 1849*a*, p. 214 (also as *E. erecta*); 1871, pl. CCCXL.
Agardh, 1883, p. 152 (as *E. erecta*), p. 153.
Hauck, 1885, p. 429.
DeToni, 1889, p. 133; p. 132 (as *E. plumosa*).
Collins, 1903, p. 28, pl. 43, fig. 4; 1909*a*, p. 198 (as *E. plumosa*), p. 200 (as *E. erecta*), p. 199.
Collins, Holden and Setchell, 1905, D (No. 78).
Setchell and Gardner, 1920*a*, p. 257 (as *E. salina*), p. 259, p. 260 (as *E. plumosa* and *E. erecta*); 1930, p. 137 (as *E. plumosa*).
Newton, 1931, p. 68.

Hamel, 1928, p. 162, figs. 49, a–d, 50, f–m, 51, I–IV.
Bliding, 1933, p. 236, figs. 3–7; 1944, p. 331, figs. 1–9; 1955, p. 261, fig. 6c; 1963, p. 107–113, figs. 64–68.
Levring, 1935, p. 8; 1937, p. 21.
Taylor, 1937, p. 63, pl. 3, fig. 1; 1957, p. 63, pl. 3, fig. 1.
Smith, 1944, p. 51.
Doty, 1947, p. 16.
Kylin, 1949, p. 28, figs. 27–29.
Waern, 1952, p. 37, fig. 17, a.
Chapman, 1956, p. 420, fig. 69 (as *E. clathrata* var. *plumosa*).
Scagel, 1957, p. 38.
Dangeard, 1964, p. 173.

Habitat. On stones, epiphytic on other algae, or floating in slightly brackish water in the middle intertidal zone.

Type Locality. Baltic Sea.

Pacific Coast Distribution. Valdez, Alaska, to Mexico.

Enteromorpha compressa (Linnaeus) Greville, 1830, p. 180.
Pl. 23, figs. C–F.

Thallus light to dark green, attached by a discoid holdfast of rhizoidal cells, frequently gregarious; several centimetres to 30 cm high, tubular, tapering toward the base and compressed or flattened distally; sometimes unbranched or sparingly branched, but generally profusely branched; branches simple, arising chiefly from the narrow basal main axes of the thallus. Branches in distal flattened portion of the thallus up to 20 mm wide, in the basal cylindrical portion 2–20 mm wide. Cells medium-sized, more or less polygonal with slightly rounded corners; irregularly arranged in older portions of plant although younger branches have cells in more or less longitudinal rows. Cells in surface view 8–10 (–16) μ in diameter, usually somewhat larger in the older portion of thallus; chloroplast laminate with one pyrenoid. In transverse section, thallus is usually less than 20 μ but may be up to 35 μ in thickness; cells usually centrally located, but may be slightly closer to the outer surface of the tubular thallus and are up to 15 (–25) μ high and about 10 μ in diameter.

Vegetative reproduction occurs by quadriflagellate zoospores; the zoospores are 9.8–11.7 μ in length and 4.9–5.9 μ wide.

Sexual reproduction is indistinctly anisogamous with biflagellate gametes; 16–32 gametes are produced by the gametangium; parthenogenetic development of gametes also occurs. There is an alternation of isomorphic generations; the plants are unisexual.

Several varieties of *Enteromorpha compressa* have been described, but only one is recognized on this Coast (*E. compressa* var. *compressa*). It is difficult, using vegetative criteria, to distinguish sparingly branched or unbranched plants of *E. compressa* from varieties of *E. intestinalis*.

References:

Linnaeus, 1755, p. 433 (as *Ulva compressa*).
Roth, 1797, p. 161; 1806, p. 175 (as *Conferva compressa*).
Lyngbye, 1819, p. 64, pl. 15, A, figs. 1, 2 (as *Scytosiphon compressus*).
Greville, 1830, p. 180, pl. 18, figs. 1–3.
Postels and Ruprecht, 1840, p. 21 (as *E. fascia*).

Harvey, 1849*a*, p. 213; 1858, p. 57; 1862, p. 176; 1871, pl. CCCXXXV.
Hauck, 1885, p. 428.
DeToni, 1889, p. 126.
Collins, Holden and Setchell, 1902, XX (No. 964).
Collins, 1903, p. 25, pl. 42, figs. 11, 12; 1909*a*, p. 201; p. 204 (as *E. fascia*); 1913, p. 101.
Setchell and Gardner, 1903, p. 213; 1920*a*, p. 251, pl. 14, figs. 7, 8, pl. 16, fig. 3.
Newton, 1931, p. 70.
Hamel, 1928, p. 156, figs. 47, 48.
Bliding, 1933, p. 244, figs. 11–13; 1948, p. 128, figs. 5–10; 1963, p. 132–136, figs. 82–84.
Levring, 1935, p. 7; 1937, p. 20.
Taylor, 1937, p. 64, pl. 3, fig. 3; 1957, p. 64, pl. 3, fig. 3.
Moewus, 1938, p. 398–423, figs. 13–20, tables 17–35.
Smith, 1944, p. 52, pl. 5, fig. 7.
Dawson, 1944, p. 203.
Doty, 1947, p. 14.
Kylin, 1949, p. 22, figs. 14, 15.
Waern, 1952, p. 35, fig. 14, b.
Chapman, 1956, p. 406.
Scagel, 1957, p. 38.
Comps, 1960*a*, p. 55–62, pls. 3, 4.
Noda, 1962, p. 76, figs. 4, 5.

Habitat. On rocks and other algae in the upper and middle intertidal zones.

Type Locality. Sweden (LINN).

Pacific Coast Distribution. Bering Sea to Costa Rica and Chile.

Enteromorpha crinita (Roth) J. Agardh, 1883, p. 145.
Pl. 25, figs. A–E.

Thallus at first attached, later free-floating, filiform, cylindrical or slightly compressed, 0.5–2.5 (–4) mm in diameter, 10–40 cm long, much and repeatedly branched, the branches fine and short, tapering to the apices and usually terminating in a uniseriate series of short cells.

Cells in longitudinal series, somewhat elongate in surface view, 8–10 (–12) μ wide and 10–15 (–25) μ long; with a single chloroplast, which nearly fills the cell, and usually one pyrenoid.

Thallus up to 20 (–30) μ thick in transverse sectional view with cells up to 17 (–25) μ high and 12 μ wide.

Reproduction and life-history details are apparently unknown in this species.

References:

Roth, 1797, p. 162, pl. 1, fig. 3; 1806, p. 174 (as *Conferva crinita*).
Kützing, 1856, p. 14, pl. 39, c (as *E. complanata* var. *crinita*).
Agardh, 1883, p. 145.
Hauck, 1885, p. 429 (as *E. clathrata* var. *crinita*).
DeToni, 1889, p. 129.
Collins, Holden and Setchell, 1898, X (No. 460).
Saunders, 1901, p. 412.
Setchell and Gardner, 1903, p. 214; 1920*a*, p. 258.
Collins, 1903, p. 26, pl. 42, fig. 14; 1909*a*, p. 199; 1913, p. 101.

Newton, 1931, p. 69.
Hamel, 1928, p. 165, fig. 50, f, g (as *E. clathrata* var. *crinita*)
Taylor, 1937, p. 62; 1957, p. 64 (as *E. clathrata*).
Chapman, 1956, p. 409, fig. 52, a–e (as *E. prolifera* var. *crinita*).
Dawson, 1961, p. 373.
Bliding, 1963, p. 119–127, figs. 73–78 (as *E. ramulosa*).
Dangeard, 1964, p. 172.

Habitat. Growing on wood and floating in the intertidal zone.

Type Locality. In the North Atlantic, near Eckwarden, East Friesland, Germany (*Conferva crinita*).

Pacific Coast Distribution. Valdez, Alaska, to San Diego, California, and in the Galapagos Islands.

Enteromorpha intestinalis (Linnaeus) Link, 1820, p. 5.

Thallus yellowish green, simple or occasionally with a few proliferous branches, solitary or gregarious, at first attached, later becoming free-floating, 1–20 (–200) cm high; cylindrical and stipitate below, generally inflated or flattened distally, often much constricted or crisped.

Cells in surface view in no regular order, 10–16 μ in diameter above, smaller toward base. In transverse section the thallus is thicker below than above, from 20–50 μ in thickness; cells 12–30 μ high and (8–) 10–16 μ wide, and closer to the outer than the inner surface of the tubular thallus. A single chloroplast, almost filling the cell, with usually one, but occasionally two or three, pyrenoids.

There is an alternation of isomorphic generations.

Vegetative reproduction occurs by proliferation from a perennial holdfast, by fragmentation and by mitospores (aplanospores and quadriflagellate zoospores) and meiospores (quadriflagellate zoospores). The zoospores are 8–9.5 μ long and 4.5–5.5 μ wide.

Sexual reproduction is by terminally biflagellate anisogametes; parthenogenesis does not usually occur, although it has been reported in one form. The male gametes are 5.0–5.6 μ long and 1.8–2.2 μ wide; female gametes are 6.0–6.8 μ long and 3.0–3.5 μ wide.

Four varieties of this species have been recorded for this area (*E. intestinalis* var. *clavata*, *E. intestinalis* var. *cylindracea*, *E. intestinalis* var. *intestinalis*, and *E. intestinalis* var. *maxima*). The criteria for distinguishing these entities have been based chiefly on size and gross morphology of the thallus. The thickness of the thallus varies greatly depending upon the environmental conditions. However, representatives of the species have not been sufficiently studied in the living condition to determine the validity of these distinctions. Although these forms may eventually be found to be ecological variants of one variable species, for the present they are considered as distinct varieties. The following key indicates the criteria used to distinguish these varieties.

KEY TO THE VARIETIES OF ENTEROMORPHA INTESTINALIS

1. Thallus very long and slender, above the stipitate region cylindrical and of uniform diameter throughout (3–10 mm diameter) .... *E. intestinalis* var. *cylindracea*, p. 50

1. Thallus otherwise 2
  2. Thallus free-floating, reaching extreme dimensions, irregularly inflated and bullate, up to 4 cm in diameter .... *E. intestinalis* var. *maxima,* p. 52
  2. Thallus otherwise 3
3. Thallus attached, filiform below, enlarging abruptly above into a clavate, irregularly swollen apex; usually open at the end; up to 5 cm or more in diameter in the apical region .... *E. intestinalis* var. *clavata,* p. 50
3. Thallus usually attached, but sometimes free-floating; tubular at the base, becoming slightly compressed and expanded above; usually less than 20 cm tall .... *E. intestinalis* var. *intestinalis,* p. 51

Enteromorpha intestinalis var. **clavata** J. Agardh, 1883, p. 131.
Pl. 28, fig. C.

Thallus attached, filiform below, enlarging abruptly above into a clavate, dilated, irregularly swollen apex; usually open at the end; 1–50 (–200) cm long and (0.5–) 1–5 (–10) cm or more in diameter in the apical region.

Structure of the thallus and arrangement of cells as described for the species (*see* p. 50).

References:
Agardh, 1883, p. 131.
Hauck, 1885, p. 426, fig. 188 (as *E. intestinalis* f. *genuina*).
DeToni, 1889, p. 123 (as *E. intestinalis* f. *genuina*).
Collins, Holden and Setchell, 1902, XX (No. 966).
Setchell and Gardner, 1903, p. 212 (as *E. intestinalis* f. *genuina*); 1920*a*, p. 253.
Collins, 1903, p. 23; 1909*a*, p. 205; 1913, p. 102.
Taylor, 1937, p. 66, pl. 3, fig. 4; 1957, p. 66, pl. 3, fig. 4.
Bliding, 1948, p. 124.
Scagel, 1957, p. 39.

Habitat. Attached to pebbles in the middle intertidal zone.

Type Locality. Devon, England (LD 13889).

Pacific Coast Distribution. Kukak Bay, Alaska, to Mexico.

Enteromorpha intestinalis var. **cylindracea** J. Agardh, 1883, p. 131.
Pl. 28, fig. D.

Thallus usually free-floating, very long and slender, stipitate below; cylindrical and of uniform diameter throughout, 3–10 mm in diameter.

Structure of the thallus and arrangement of cells as described for the species (*see* p. 50).

References:
Ahlner, 1877, p. 20 (as *E. intestinalis* f. *attenuata*).
Agardh, 1883, p. 131.
Hauck, 1885, p. 426.
DeToni, 1889, p. 123.
Collins, Holden and Setchell, 1898, X (No. 465).
Saunders, 1901, p. 411.
Setchell and Gardner, 1903, p. 212; 1920*a*, p. 252.
Collins, 1903, p. 23; 1909*a*, p. 205; 1913, p. 102.
Taylor, 1937, p. 66, pl. 3, figs. 5, 6; 1957, p. 67, pl. 3, figs. 5, 6.
Sjöstedt, 1940, p. 12, figs. 4, 7.
Dawson, 1946, p. 7.
Scagel, 1957, p. 39.

Habitat. Usually floating unattached in sheltered waters.

Type Locality. Probably Sweden.

Pacific Coast Distribution. Popof Island, Alaska, to Mexico.

Enteromorpha intestinalis (Linnaeus) Link var. **intestinalis,** 1820, p. 5.
Pl. 26, figs. A–Q; pl. 27, figs. A–E.

Thallus yellowish green, simple or gregarious, usually attached but sometimes free-floating, tubular, and stipitate at the base, becoming slightly compressed and expanded above and usually contorted or crisped; usually less than 20 cm tall.

Cells in surface view in no regular order, 10–16 μ in diameter above, 5–10 μ in diameter near the base. In transverse section the thallus is 20–50 μ in thickness, thicker above than below (40–50 μ near the base and up to 25 μ near the apex); cells 12–30 μ high and (8–) 10–16 μ wide, and closer to the outer than the inner surface of the tubular thallus. A single chloroplast almost fills the cell; with one (occasionally two or three) pyrenoids.

There is an alternation of isomorphic generations (*see* discussion on p. 23).

Vegetative reproduction occurs by proliferation from a perennial holdfast, by fragmentation, and by mitospores (aplanospores and quadriflagellate zoospores) and meiospores (quadriflagellate zoospores). A morphologically similar, free-living, multicellular phase (not involved in the typical alternation of generations) can arise from mitospores (which may perhaps be haploid or diploid) as an accessory method of reproduction.

Sexual reproduction is by terminally biflagellate anisogametes; parthenogenesis does not apparently occur.

References:

Linnaeus, 1753, p. 1163; 1755, p. 432 (as *Ulva intestinalis*).
Link, 1820, p. 5.
Kützing, 1849, p. 478; 1856, p. 11, pl. 31, a–c.
Harvey, 1849*a*, p. 213; 1858, p. 57; 1862, p. 176; 1871, pl. CLIV.
LeJolis, 1863, p. 46 (as *Ulva enteromorpha* var. *intestinalis*).
Ahlner, 1877, p. 15, fig. 1, a, b.
Agardh, 1883, p. 131, pl. 4, fig. 109.
Hauck, 1885, p. 426.
Wolle, 1887, p. 107, pl. 125, figs. 9, 10.
DeToni, 1889, p. 123.
Collins, Holden and Setchell, 1898, X (No. 464).
Saunders, 1901, p. 411.
Collins, 1903, p. 23, pl. 42, figs. 6, 7; 1909*a*, p. 204; 1913, p. 102.
Setchell and Gardner, 1903, p. 212; 1920*a*, p. 252.
Howe, 1914, p. 24.
Kylin, 1930, p. 458, figs. 1–10.
Hamel, 1928, p. 157, fig. 47, II (as *E. compressa* var. *intestinalis*).
Newton, 1931, p. 70.
Smith, 1933, p. 454, fig. 306; 1944, p. 49, pl. 5, figs. 4–6; 1950, p. 188, fig. 115.
Fritsch, 1935, p. 217, fig. 64; p. 215, fig. 63, B.
Taylor, 1937, p. 65, pl. 3, fig. 7, pl. 4, figs. 4, 5; 1957, p. 66, pl. 3, fig. 7, pl. 4, figs. 4, 5.
Moewus, 1938, p. 374–398, tables 4–16, figs. 4–12.
Sanborn and Doty, 1947, p. 24.

Doty, 1947, p. 14.
Bliding, 1948, figs. 1–4, 10, a–d; 1963, p. 139–141, figs. 87, 88.
Rigg and Miller, 1949, p. 332.
Kylin, 1949, p. 22, fig. 13.
Silva, 1952, p. 294.
Waern, 1952, p. 32, figs. 14, 15.
Tokida, 1954, p. 54.
Chapman, 1956, p. 404, fig. 47, h.
Scagel, 1957, p. 39.
Dangeard, 1959*b*, p. 177–181.
Christie and Evans, 1962, p. 193, 194, fig. 1.

Habitat. On rocks or epiphytic on other algae in the upper intertidal zone, particularly in somewhat brackish water.

Type Locality. Probably Sweden (*Ulva intestinalis* Linnaeus, 1755).

Pacific Coast Distribution. Kukak Bay, Alaska, to Mexico and Chile.

Enteromorpha intestinalis var. **maxima** J. Agardh, 1883, p. 132.

Thallus free-floating, reaching extreme dimensions, irregularly inflated and bullate; up to 4 cm in diameter; often producing small scattered proliferous branches.

Structure of the thallus and arrangement of cells as described for the species (*see* p. 50).

References:
Agardh, 1883, p. 132.
Saunders, 1901, p. 411.
Setchell and Gardner, 1903, p. 212; 1920*a*, p. 253.
Collins, 1903, p. 23; 1909*a*, p. 205; 1913, p. 102.
Newton, 1931, p. 70.
Levring, 1937, p. 20.
Taylor, 1937, p. 66; 1957, p. 67.
Dawson, 1946, p. 7.
Scagel, 1957, p. 40.

Habitat. Usually floating unattached in sheltered waters.

Type Locality. In the North Sea, probably from Germany.

Pacific Coast Distribution. Kukak Bay, Alaska, to Mexico.

Enteromorpha linza (Linnaeus) J. Agardh, 1883, p. 134.
Pl. 24, figs. A–F.

Thallus yellowish green, simple, often gregarious, to 45 (–50) cm long, 1–4 (–10) cm wide; lanceolate, or linear and usually broadening terminally; with smooth, crisped, or ruffled margins; flat portion of thallus distromatic; margins of blades frequently becoming hollow through a separation of the two cell layers. Base of blade tapering to a hollow cylindrical stipe which is at times spirally twisted.

In surface view, cells rectangular to vertically elongate; 10–15 (–20) μ in diameter in distal flattened portion of thallus and in no definite order; cells in stipitate region in longitudinal rows and up to 30 μ in length; chloroplast laminate to cup-shaped with usually one pyrenoid. In sectional view the distromatic portion of the thallus is (25–) 35–40 (–70) μ thick; cells are 10–15 (–18) μ wide and 15–30 μ high. In the tubular basal portion the monostromatic thallus is up to 30 μ thick in sectional view, and the cells are up to 10 μ wide and 25 μ high; the cells are closer to the outer surface.

Vegetative reproduction occurs by biflagellate and quadriflagellate zoospores; biflagellate zoospores are probably mitospores (and may be haploid or diploid), but the quadriflagellate zoospores may be either mitospores or meiospores.

Sexual reproduction occurs by biflagellate isogametes.

There is an alternation of isomorphic generations.

Several varieties of *Enteromorpha linza* have been described. Only one (*E. linza* var. *linza*) is recognized in this treatment. At this stage in our knowledge of the ecology and reproduction of the Pacific Coast entity, and subject to a more satisfactory treatment of the species and genus, it is impossible to appraise the validity of the vegetative criteria used to distinguish the varieties described.

References:

Linnaeus, 1753, p. 1163; 1755, p. 433 (as *Ulva linza*).
Agardh, 1822, p. 412 (as *Ulva linza*).
Kützing, 1849, p. 475; 1856, p. 7, pl. 17 (as *Phycoseris*).
Harvey, 1849*a*, p. 216; 1862, p. 176; 1871, pl. XXXIX (as *Ulva linza*).
Agardh, 1883, p. 134, pl. 4, figs. 110–112.
Hauck, 1885, p. 427.
DeToni, 1889, p. 124.
Collins, Holden and Setchell, 1895, I (No. 16); 1902, XX (No. 967) (as *E. linza* var. *lanceolata*).
Collins, 1903, p. 23, pl. 42, fig. 8; 1909*a*, p. 206; 1913, p. 102.
Setchell and Gardner, 1903, p. 213 (as *E. linza* f. *lanceolata*), p. 212; 1920*a*, p. 262, pl. 12, figs. 1–4 (as *Ulva linza*).
Howe, 1914, p. 24.
Hamel, 1928, p. 155, fig. 46, E–G.
Newton, 1931, p. 78 (as *Ulva linza*).
Bliding, 1933, p. 234, figs. 1, 2; 1939, p. 139, figs. 4–7; 1963, p. 127–130, figs. 79–81.
Levring, 1935, p. 6; 1937, p. 18 (as *Ulva linza*).
Taylor, 1937, p. 68, pl. 3, fig. 8; 1957, p. 68, pl. 3, fig. 8.
Yamada and Saito, 1938, p. 40, figs. 6–8.
Moewus, 1938, p. 424–432, tables 36–39, figs. 21–24.
Sjöstedt, 1939, p. 58.
Smith, 1944, p. 44, pl. 3, figs. 4, 5 (as *Ulva linza*).
Arasaki, 1946, p. 281, fig. 1.
Doty, 1947, p. 18, pl. 1, figs. 7–9.
Sanborn and Doty, 1947, p. 24 (as *Ulva linza*).
Kylin, 1949, p. 19, fig. 12.
Rigg and Miller, 1949, p. 332 (as *Ulva linza*).
Tokida, 1954, p. 55.
Chapman, 1956, p. 386, fig. 38, a–c (as *Ulva linza*).
Scagel, 1957, p. 41.
Arasaki and Shihara, 1959, p. 92, figs. 1, 2.
Papenfuss, 1960, p. 311.
Levring, 1960, p. 10 (as *Ulva linza*).
Comps, 1960*a*, p. 45–55, pls. 1, 2; 1960*b*, p. 2067–2069, figs. A–D.
Dangeard, 1960*a*, p. 103, figs. 1–4, pl. 1; 1964, p. 173.
Noda, 1962, p. 76, figs. 6, 7.

Habitat. On rocks or epiphytic on other algae in the lower intertidal zone.

Type Locality. In the Ocean (probably England) (Linnaeus).

Pacific Coast Distribution. Orca, Alaska, to Mexico and Chile.

Enteromorpha marginata J. Agardh, 1842, p. 16.*
Pl. 27, figs. H, I.

Thallus deep green, simple or with a few proliferous branches, gregarious, filiform or slightly compressed, 2–3 (–5) cm high, 15–30 (–200) μ in diameter (seldom over 20 cells wide).

Cells in regular longitudinal rows, especially along the margins, somewhat elongate, 5–8 (–10) μ long and about 5 μ wide in surface view; in transverse sectional view, cells about 6 μ high and 5 μ wide; with a single chloroplast, almost completely filling the cell, and with one pyrenoid.

Reproduction and life-history details are apparently unknown for this species, except for the occurrence of quadriflagellate zoospores and early stages in their germination.

References:

Agardh, 1842, p. 16; 1883, p. 142.
Kützing, 1849, p. 481; 1856, p. 15, pl. 41, figs. 1, 2.
Hauck, 1885, p. 432.
DeToni, 1889, p. 127.
Collins, Holden and Setchell, 1898, X (No. 466).
Collins, 1903, p. 25, pl. 42, fig. 13; 1909*a*, p. 202; 1913, p. 102.
Setchell and Gardner, 1920*a*, p. 257.
Hamel, 1928, p. 152, fig. 46A.
Taylor, 1937, p. 65; 1957, p. 65.
Scagel, 1957, p. 41.
Chapman, 1956, p. 416, fig. 63, a–d (as *E. nana* var. *marginata*).
Dangeard, 1958*a*, p. 347, figs. A–K; 1964, p. 174 (as *Blidingia marginata*).
Bliding, 1963, p. 32–37, figs. 12, 13 (as *Blidingia marginata*).

Habitat. Epiphytic on spermatophytes, usually in salt marshes, but also on other substrata in the intertidal zone.

Type Locality. Mediterranean Sea (LD 14161).

Pacific Coast Distribution. Southern British Columbia to California.

Enteromorpha prolifera (Müller) J. Agardh var. **prolifera**, 1883, p. 129.
Pl. 28, figs. E–G.

Thallus dark to light green, to several metres in length, (0.5–) 1.5–2 cm in diameter, solitary or gregarious, tubular or compressed; usually with a distinct main axis and with numerous proliferous branches; branches usually simple, but sometimes also with proliferous branches; narrowly stipitate at the base and usually remaining attached.

In surface view cells more or less rectangular near the base, squarish above, (8–) 10–18 (–30) μ long and (5–) 7–10 (–15) μ wide, in longitudinal series in younger parts and branches, but more irregular in older parts.

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*On the basis of culture studies, Dangeard (1958) has presented fairly convincing evidence that the method of zoospore germination and basal structure of the juvenile thallus of this entity justify referring the plant to the genus *Blidingia*.

Chloroplast single, only partially filling the cell, with usually one pyrenoid (occasionally 2–3).

In transverse section thallus is (14–) 15–20 (–35) μ thick; the cells are centrally located and are up to 25 μ high and 10–15 μ wide.

Vegetative reproduction takes place by quadriflagellate zoospores (meiospores) about 4.4 μ wide and 9.1 μ long.

Sexual reproduction is anisogamous; male gametes are on the average 2.2 μ wide and 5.7 μ long; female gametes are on the average 2.9 μ wide and 6.2 μ long.

There is an alternation of isomorphic generations.

References:

Müller, 1778, p. 7, pl. 763, fig. 1 (as *Ulva prolifera*).
Agardh, 1822, p. 421 (as *Ulva compressa* var. *prolifera*).
Greville, 1830, p. 180, pl. 18 (as *Ulva compressa* var. *prolifera*).
Kützing, 1856, p. 11, pl. 30, fig. 3, a–e (as *E. pilifera*).
Ahlner, 1877, p. 35 (as *E. compressa* var. *prolifera*).
Agardh, 1883, p. 129, pl. 4, figs. 103, 104.
Hauck, 1885, p. 427 (as *E. intestinalis* f. *prolifera*).
DeToni, 1889, p. 122.
Rosenvinge, 1893, p. 960.
Saunders, 1901, p. 411.
Setchell and Gardner, 1903, p. 211; 1920*a*, p. 254.
Collins, 1903, p. 21, pl. 42, fig. 5; 1909*a*, p. 202; 1913, p. 102.
Howe, 1914, p. 23.
Collins, Holden and Setchell, 1919, XLVI (No. 2283).
Hamel, 1928, p. 160, fig. 48, 1–4 (as *E. compressa* var. *prolifera*).
Newton, 1931, p. 69.
Bliding, 1933, p. 240, figs. 8–10; 1939, p. 134, figs. 1–3; 1963, p. 45-56, figs. 19–23.
Levring, 1937, p. 21.
Taylor, 1937, p. 65, pl. 3, fig. 2; 1957, p. 65, pl. 3, fig. 2.
Doty, 1947, p. 14.
Kylin, 1949, p. 25, figs. 18–20.
Waern, 1952, p. 35, fig. 16 g, h.
Tokida, 1954, p. 53, pl. 4, figs. 11–16.
Chapman, 1956, p. 408, fig. 51, a, b.
Scagel, 1957, p. 42.
Dangeard, 1958*d*, p. 147, pl. 1.
Dawson, 1961, p. 374.

Habitat. On sticks and stones and epiphytic on other algae in the lower intertidal zone in sheltered bays, often floating.

Type Locality. In the North Sea, near Nebel, North Friesland, Germany.

Pacific Coast Distribution. Golovnin Bay, Alaska, to Central Mexico and Peru.

Enteromorpha torta (Mertens) Reinbold, 1893, p. 201.
Pl. 27, fig. J; pl. 28, figs. A, B.

Thallus small, 1–3 cm in length, 30–80 μ in diameter, simple or occasionally branched, with branches biseriate (occasionally uniseriate when young); growing in intertwined masses, frequently tangled with other algae.

Cells rectangular in surface view, about 10 μ wide and 20–25 μ long, in distinct longitudinal rows and more or less cross rows; usually only four to eight cells (occasionally more) making up the circumference of the main axis of the tubular thallus; lumen of tubular thallus quite small. Chloroplast single and covering greater part of cell; with one pyrenoid.

Reproduction and life-history details are apparently unknown in this species.

References:

Mertens, 1816–22 (as *Conferva torta*).
Reinbold, 1893, p. 201.
Collins, Holden and Setchell, 1896, V (No. 223).
Collins, 1903, p. 26, pl. 42, fig. 4; 1909*a*, p. 198.
Setchell and Gardner, 1920*a*, p. 258.
Newton, 1931, p. 68.
Hamel, 1928, p. 154, fig. 46, B, C.
Taylor, 1937, p. 62; 1957, p. 63.
Jao, 1937, p. 103.
Chapman, 1956, p. 410, fig. 53, a–c (as *E. prolifera* var. *torta*).
Scagel, 1957, p. 42.
Bliding, 1963, p. 41–43, figs. 16, 17.
Dangeard, 1964, p. 173.

Habitat. Attached to rocks in shallow pools in the upper intertidal zone; also in lagoons.

Type Locality. In the North Atlantic, probably near Kiel, Germany.

Pacific Coast Distribution. Southern British Columbia to San Diego, California.

Enteromorpha tubulosa Kützing, 1856, p. 11.[*]
Pl. 27, figs. F, G.

Thallus 4–8 (–30) cm high, up to 150 μ in diameter, simple or with occasional short proliferous branches, gregarious, often nearly cylindrical throughout, but at times cylindrical in the basal region only and slightly compressed in the upper region.

The cells are in regular longitudinal series throughout, slightly elongate in surface view, 7–10 μ in diameter and up to 20 μ long. In transverse section the thallus is (15–) 20–25 (–30) μ thick and the cells are (10–) 12–15 (–20) μ high and 10–15 μ wide. The single chloroplast is cup-shaped, toward the outer part of the cell, and has one or more (usually two or three) pyrenoids.

Reproduction and life-history details are apparently unknown in this species (*see also* * below).

References:

Kützing, 1856, p. 11, pl. 32, fig. 2.
Ahlner, 1877, p. 49, fig. 9, a, b.
Agardh, 1883, p. 128.
Reinbold, 1889, p. 117 (as *E. prolifera* var. *tubulosa*).
DeToni, 1889, p. 122.
Collins, Holden and Setchell, 1898, X (No. 471) (as *E. prolifera* var. *tubulosa*).

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[*] According to Kylin (1949) this entity should be included in *Enteromorpha prolifera* J. Agardh, whereas Taylor (1957) and others regard it as a variety, *E. prolifera* (Müller) J. Agardh var. *tubulosa* (Kützing) Reinbold.

Collins, 1903, p. 22; 1909*a*, p. 203 (as *E. prolifera* var. *tubulosa*).
Setchell and Gardner, 1920*a*, p. 256, pl. 14, figs. 4, 5.
Newton, 1931, p. 69 (as *E. prolifera* var. *tubulosa*).
Levring, 1935, p. 7.
Taylor, 1937, p. 65; 1957, p. 66 (as *E. prolifera* var. *tubulosa*).
Smith, 1944, p. 51, pl. 5, figs. 1–3.
Rigg and Miller, 1949, p. 332.
Kylin, 1949, p. 25 (as *E. prolifera*).
Chapman, 1956, p. 404, fig. 47, a–g (as *E. prolifera* var. *tubulosa*).
Scagel, 1957, p. 42.
Dangeard, 1958*b*, p. 45 (as *E. prolifera* var. *tubulosa*); 1959*a*, p. 889–892, figs 1–29; 1964, p. 173.
Bliding, 1963, p. 73–79, figs. 38–40 (as *E. flexuosa*).

Habitat. On rocks in the lower intertidal zone.

Type Locality. Germany.

Pacific Coast Distribution. Northern Washington to Central America and in the Galapagos Islands.

ULVA Thuret, 1854*a*, p. 28.

Thallus flattened and foliose, sometimes lobed or branched, distromatic with the two cell layers in close contact and separated by a mucilaginous matrix. The thallus may be sessile or stipitate and is attached by a holdfast of modified rhizoidal cells arising from the basal region of the plant; the holdfast may be perennial.

The ordinary vegetative cells are uninucleate (rhizoidal cells may become multinucleate) with a single, parietal, laminate chloroplast containing one or more pyrenoids.

As far as known the species of this genus have an alternation of isomorphic generations.*

Vegetative reproduction may occur by fragmentation of the thallus and, where a perennial holdfast is known, new erect branches may regenerate each season from the basal region of old plants.

The sporophytes are diploid and produce mitospores (aplanospores and zoospores) and meiospores (zoospores), from eight to sixteen per sporangium, in undifferentiated cells; the motile spores are quadriflagellate.

Sexual reproduction is isogamous or anisogamous and occurs by terminally biflagellate isogametes or anisogametes; the number of gametes produced in the gametangia varies (in some instances on the same thallus) and may be 16, 32, 64, or 128; the gametangia are undifferentiated cells; the plants are unisexual or bisexual. Parthenogenetic development of gametes has been reported in some species.

Except for the cells near the base of the thallus, and certain marginal cells which remain vegetative, all cells are potentially capable of producing zoospores or gametes.

Several species and varieties are recorded for this area, although these have been little studied in the living condition in culture to clarify life-history and reproductive characteristics. The need for a thorough study along these lines to establish the degree of variability in these entities and the extent to which morphological and anatomical criteria can be used to distinguish species has already been demonstrated in some species (Yamada and Saito. 1938; Smith, 1947; Bliding, 1960).

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*Reproduction and life histories are known in a few species in this genus, and it is assumed that isomorphism occurs in all species. However, few observations have been made on the Pacific Coast species recorded in this area in these respects, and, in some instances nothing is known of these features.

Morphology and Reproduction:

Linnaeus, 1753, p. 1163.
Wille, 1890, p. 74–79.
Schiller, 1907, p. 1691–1716, pls. 1, 2.
Delf, 1912, p. 403–408, 3 figs., pl. XLV.
Setchell and Gardner, 1920*a*, p. 260–273, pls. 12, figs. 1–4; 17, figs. 4–7; 21, figs. 1, 2; 22–24; 26.
Carter, 1926, p. 665–689, pl. 22, figs. 1–25.
Printz, 1927, p. 176, fig. 128.
Føyn, 1929, p. 503–506, fig. 2, a–f; 1934*a*, p. 154–177, figs. 1–13, tables 1–8; 1955, p. 261–270, fig. 1, pl. 17; 1958, p. 473–480, figs. 1–4; 1959, p. 236–253, figs. 1–13; 1960, p. 407–411, figs. 1–4; 1961, p. 60–64, figs. 1–6; 1962, p. 156–162, figs. 1–10.
Miyake and Kunieda, 1931, p. 351–353, figs. 56–101.
Moewus, 1938, p. 370–374, tables 3, 4.
Yamada and Saito. 1938, p. 36–40, figs. 1–5.
Arasaki, 1946, p. 285–287, fig. 3.
Smith, 1947, p. 80–87, figs. 1–38; 1955, p. 61–64, fig. 24.
Kylin, 1949, p. 17, 18, fig. 11.
Levring, 1955, p. 40–45.
Provasoli, 1958, p. 375–384, figs. 1–21.
Gayral and de Mazancourt, 1958, p. 133–141, pls. 1–3; 1959, p. 1384–1386.
Cauro, 1958, p. 89–141, pls. III–IX, fig. 1.
Gayral, 1959, p. 85–100, pls. 1, 2; 1960*a*, p. 3–96, pls. 1, 2; 1960*b*, p. 768–770; 1961*a*, p. 223–228, figs. A–C; 1964, p. 79–88, figs. 1, 2.
Papenfuss, 1960, p. 303–305, figs. 1–9.
Dangeard, 1960*b*, p. 119–147, figs. 1–11, pls. I–IV.
Yabu and Tokida, 1960, p. 182–185, figs. 1–27.
Hoek, 1964*b*, p. 38–42.

Key to the Species of Ulva

1. Cells in transverse section vertically elongate, in middle of thallus 2
1. Cells in transverse section quadrate throughout; thallus ovate, often large and broadly expanded, attached or free-floating, sometimes deeply split .... *U. lactuca*, p. 60
   2. Thallus with abundant and regular perforations .... *U. fenestrata*, p. 59
   2. Thallus not perforated 3
3. Thallus large, with deep ruffled margins .... *U. expansa*, p. 58
3. Thallus small, not ruffled along the margins 4
   4. Thallus narrow in proportion to height .... *U. vexata*, p. 62
   4. Thallus broad in proportion to height, usually deeply split .... *U. rigida*, p. 61

Ulva expansa (Setchell) Setchell and Gardner, 1920*b*, p. 284.
Pl. 29, figs. A, B.

Thallus pale green, large and elongate or orbicular, varying in width. 20–30 (–150) cm broad and up to 1 (–3) m in length, with deeply ruffled entire margins; 50–70 μ thick in the middle of the blade, 35–45 μ thick at the margins; generally free-floating at maturity.

In surface view, cells vertically elongate in the middle of the thallus, more or less quadrate near the margins, (10–) 15–20 μ in diameter. In transverse section, cells in the middle 25–35 μ in height and 10–20 μ in width; at the margins somewhat smaller and subquadrate. There is a single laminate chloroplast which contains usually one, but often two or three large pyrenoids.

Reproduction and life-history details are apparently unknown in this species.

References:
Setchell, *in* Collins, Holden and Setchell, 1905, D (No. LXXVII) (as *U. fasciata* f. *expansa*).
Collins, 1909*a*, p. 216 (as *U. fasciata* f. *expansa*).
Setchell and Gardner, 1920*a*, p. 268; 1920*b*, p. 284.
Smith, 1944, p. 46.
Sanborn and Doty, 1947, p. 24.
Doty, 1947, p. 10.
Scagel, 1957, p. 43.

Habitat. On rocks or epiphytic on other algae in the lower intertidal and subtidal zones; or floating in quiet water.

Type Locality. Near Fisherman's Wharf, Monterey, California.

Pacific Coast Distribution. Southern British Columbia to Mexico.

Ulva fenestrata Postels and Ruprecht, 1840, p. 21.
Pl. 29, figs. C–E.

Thallus yellowish green, broad, more or less ovoid and expanded, (6–) 40 cm—4 m high, and up to 130 cm wide; more or less uniformly perforated with large and small rounded or irregularly elongate holes; at margins perforations split open and give rise to narrow marginal segments; margin usually entire, often slightly wavy.

In surface view cells are 20–22 μ in diameter. In transverse section the thallus is 35–45 (–70) μ in thickness; cells are vertically elongate, taller in the middle of the thallus than toward the margin, 15–20 μ tall, up to 16 μ wide. The chloroplast is laminate, toward the outer face of the cell, only partially filling the cell, and usually contains a single pyrenoid.

Reproduction and life-history details are apparently unknown in this species.

References:
Postels and Ruprecht, 1840, p. 21, pl. 37.
Setchell and Gardner, 1920*a*, p. 267.
Sanborn and Doty, 1947, p. 24.
Doty, 1947, p. 9, pl. 2, fig. 3.
Scagel, 1957, p. 43.

Habitat. On rocks and free-floating in the lower intertidal and upper subtidal zones.

Type Locality. Kamtschatka (Postels and Ruprecht, 1840).

Pacific Coast Distribution. Sitka, Alaska, to Oregon.

Ulva lactuca Linnaeus, 1753, p. 1163.
Pl. 31, figs. I–K.

Thallus light to dark green, 18–60 cm long, lanceolate to broadly ovate, entire or often ruffled along the margins, at times irregularly laciniate; attenuate near the base and attached by a small discoid holdfast.

In transverse section the thallus is thicker in the middle and thinner toward the margins, (35–) 40–50 μ thick; the cells, which are 15–20 μ tall, are nearly square or slightly elongate horizontally with rounded corners. In surface view the cells are irregularly arranged, somewhat angular, and (8–) 10–15 (–20) μ in diameter. There is a laminate chloroplast which is confined to the outer half of the cell and contains one to three pyrenoids.

Reproduction and life-history details are as described for the genus, with conspicuous anisogamy; the plants are unisexual. Parthenogenetic development of gametes is recorded.

Several varieties of *Ulva lactuca* have been described, but only one (*U. lactuca* var. *lactuca*) is recognized in this area.

A plant known as *Ulva latissima*, which has also been considered as a variety of *U. lactuca* (*U. lactuca* var. *latissima*) by some authors, has been distinguished by the following criteria: it is larger, often torn, broadly expanded, 1–3 m in length and equally broad, and often bullate (rather than being ovate and smooth), and is usually free-floating. However, it has been reported (Papenfuss, 1960, p. 303) that the type upon which this taxon is based is, in fact, a species of *Laminaria*. Hence, those records and criteria applying to *bona fide* plants of *Ulva* should be reduced to synonymy under the typical variety, *U. lactuca* var. *lactuca*, as is done here, or referred to a new variety if it is indeed distinct from the typical variety. The Pacific Coast distribution of the entities on this Coast formerly referred to *Ulva latissima* is from Juneau, Alaska, to Northern Washington.

References:

Linnaeus, 1753, p. 1163; 1755, p. 433.
DeLamarck and DeCandolle, 1805, p. 9.
Harvey, 1849*a*, p. 216 (also as *U. latissima*); 1858, p. 60; p. 59 (as *U. latissima*); 1862, p. 176 (as *U. latissima*); 1871, pl. CCXLIII; pl. CLXXI (as *U. latissima*).
Thuret, 1854*a*, p. 24.
Bailey and Harvey, 1862, p. 163 (as *U. lactuca* var. *latissima*).
LeJolis, 1863, p. 38 (as *U. lactuca* var. *latissima*).
Thuret and Bornet, 1878, p. 5, pls. 2, 3 (also as *U. latissima*).
Hauck, 1885, p. 435.
DeToni, 1889, p. 111 (also as *U. lactuca* f. *genuina*).
Rosenvinge, 1893, p. 939.
Saunders, 1901, p. 410 (as *U. lactuca* var. *myriotrema*).
Collins, 1903, p. 8; p. 9 (as *U. latissima*); 1909*a*, p. 214, pl. 7, fig. 75; p. 215 (as *U. lactuca* var. *latissima*); 1913, p. 103 (as *U. lactuca* var. *latissima*).
Setchell and Gardner, 1903, p. 210 (as *U. lactuca* var. *latissima*); 1920*a*, p. 266 (as *U. latissima*).
Oltmanns, 1904, p. 205, fig. 131.
Collins, Holden and Setchell, 1905, D (No. LXXVI) (as *U. lactuca* var. *latissima*).
Schiller, 1907, p. 1691, pls. 1, 2.
Howe, 1914, p. 18.
Carter, 1926, p. 665, pl. 22, figs. 1–25.
Connell, 1928, p. 100 (as *U. lactuca* f. *latissima*).
Hamel, 1928, p. 140; p. 141 (as *U. lactuca* var. *latissima*).
Newton, 1931, p. 77, fig. 57; p. 78 (as *U. lactuca* var. *latissima*).

Føyn, 1934*a*, p. 154; 1955, p. 261, pl. 17.
Fritsch, 1935, p. 213, fig. 62.
Levring, 1937, p. 18; 1955, p. 40, figs. 1, 2.
Feldmann, 1937, p. 194.
Taylor, 1937, p. 75, pl. 4, fig. 6; 1957, p. 74, pl. 4, fig. 6 (also as *U. lactuca* var. *latissima*).
Smith, 1944, p. 45, pl. 3, figs. 6, 7.
Sanborn and Doty, 1947, p. 19.
Kylin, 1949, p. 17, fig. 11 (also as *U. lactuca* f. *latissima*).
Rigg and Miller, 1949, p. 332.
Chapman, 1956, p. 388, fig. 32, Ib.
Scagel, 1957, p. 44 (also as *U. latissima*).
Provasoli, 1958, p. 375, figs. 1–21.
Papenfuss, 1960, p. 303, figs. 1–3.
Dangeard, 1960*b*, p. 121, figs. 2–5, pls. I, II: 1964, p. 172.
Levring, 1960, p. 9.

Habitat. On rocks and epiphytic on other algae in the upper intertidal zone; often floating on mud flats in the lower intertidal zone in quiet bays and lagoons.

Type Locality. Probably the west coast of Sweden (LINN).

Pacific Coast Distribution. Bering Sea to Chile.

Ulva rigida C. Agardh, 1822, p. 410.*
Pl. 30, figs. A–C; pl. 31, figs. A–H.

Thallus dark green, up to 10–15 cm high, firm and rather stiff; when young lanceolate to ovate, at maturity broadly expanded; deeply lobed and somewhat ruffled; narrowing abruptly at the base to a pronounced, short, solid stipe.

In surface view the cells are irregularly arranged with rather rounded corners, 10–15 μ in diameter. In transverse section the thallus is 60–90 (–110) μ in thickness with cells vertically elongated and in a palisade-like layer; the two layers of cells are separated by a pronounced development of the intercellular mucilaginous matrix; the cells are 10–15 μ in diameter and about 25 μ in height. Situated toward the outer face of the cell there is a single chloroplast which fills about half the cell, with usually one, sometimes two or three, conspicuous pyrenoids.

Sexual reproduction is apparently by anisogamous biflagellate gametes but life-history details are apparently still incompletely known in this species; quadriflagellate zoospores and aplanospores have been observed, and early stages in development of the thallus from these have been studied in the local plant.

References:
Agardh, 1822, p. 410.
Thuret, 1854*a*, p. 24.
LeJolis, 1863, p. 38 (as *U. lactuca* var. *rigida*).
Agardh, 1883, p. 168, pl. 4, figs. 119–122.
Kjellman, 1889, p. 53 (as *U. lactuca* var. *rigida*).

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*Superficially this species resembles *Monostroma fuscum* because of its firmness and rigidity. The plant, collected by David Lyall at Esquimalt (TCD) and identified by Harvey (1862, p. 176) as *Ulva rigida*, is a variety of *Monostroma fuscum*.

DeToni, 1889, p. 111 (as *U. lactuca* f. *genuina*).
Collins, Holden and Setchell, 1898, IX (No. 407); 1916, XLII (No. 2064).
Saunders, 1901, p. 410.
Setchell and Gardner, 1903, p. 209 (as *U. lactuca* var. *rigida*); 1920*a*, p. 269.
Collins, 1903, p. 8, pl. 41, fig. 1; 1909*a*, p. 215; 1913, p. 103 (as *U. lactuca* var. *rigida*).
Hamel, 1928, p. 140 (as *U. lactuca* var. *rigida*).
Newton, 1931, p. 77 (as *U. lactuca* var. *rigida*).
Taylor, 1937, p. 75; 1957, p. 74 (as *U. lactuca* var. *rigida*).
Feldmann, 1937, p. 197, figs. 11, 12.
Smith, 1944, p. 47.
Chapman, 1956, p. 388, fig. 32. Ia (as *U. lactuca* var. *rigida*).
Scagel, 1957, p. 45.
Papenfuss, 1960, p. 305, fig. 4.
Dangeard, 1960*b*, p. 141, figs. 10, 11, pl. IV, figs. L–Q; 1964, p. 172.
Gayral, 1961*a*, p. 223–228, figs. A–C.

Habitat. On rocks and old wood and epiphytic on other algae in the upper intertidal zone.

Type Locality. Probably Cadiz, Spain.

Pacific Coast Distribution. Uyak Bay, Alaska, to Mexico and Chile.

Ulva vexata Setchell and Gardner, 1920*b*, p. 282.
Pl. 30, figs. D–F.

Thallus dark green, small, and rigid, up to 3 cm high, linear to lanceolate, up to 1 cm wide, more or less bullate and with a short, solid, compressed stipe; usually infected with an ascomycetous fungus which produces fusiform hyphae between the cell layers and between the cells, and at maturity forms conspicuous black fruiting bodies scattered over the thallus of the alga.

Thallus in uninfected region 40–55 μ in thickness, becoming much thicker (up to 100 μ) as a result of hyphal development between the cell layers.

In surface view the cells are irregularly arranged, frequently scattered unevenly in infected regions, 5–7 μ in diameter and rather rounded.

In transverse section the cells are vertically elongated, 10–12 (–18) μ in height and 3–7 μ in diameter. The chloroplast is more or less cup-shaped and fills the cell; a single pyrenoid is present in the cell. In slightly infected portions of the thallus, and near the base, the cells in transverse section are arranged in more or less even rows; at this time most of the hyphal development is between the two cell rows of the distromatic thallus. In heavily infected regions, especially when the hyphae penetrate between the cells, the arrangement of cells becomes very irregular so that the thallus has a polystromatic appearance.

Reproduction and life-history details are apparently unknown in this species.

References:

Reed, 1902, p. 149, pl. 15, figs. 1–3 (as *Ulva californica*).
Setchell and Gardner, 1920*a*, p. 271, pl. 17, figs. 4–7; 1920*b*, p. 282, pl. 22, figs. 4–7.
Doty, 1947, p. 21, pl. 1, figs. 12–14 (as *Enteromorpha vexata*).
Dawson, 1961, p. 374.

Habitat. On rocks high in the intertidal zone on the exposed coast.

Type Locality. Near San Francisco, California.

Pacific Coast Distribution. Northern Washington (RFS 168L, Waadah Island, Washington, 15 July 1954) to San Francisco, California.

PERCURSARIA Bory, 1823, p. 393.

Thallus uniseriate and filamentous at first, soon becoming biseriate with two longitudinal rows of rectangular cells placed more or less symmetrically side by side. The erect filamentous portion may arise from a simple rhizoidal attachment region or from a discoid prostrate system of filamentous and multicellular rhizoidal branches (several erect biseriate filaments may arise from the same basal system of branches).

The cells are uninucleate with a single parietal, laminate chloroplast.

Vegetative reproduction occurs frequently by proliferation; quadriflagellate zoospores (meiospores) and diploid mitospores are also produced.

Sexual reproduction is anisogamous by terminally biflagellate gametes; parthenogenetic development of gametes is also reported, and the resulting plants may produce haploid mitospores at maturity.

There is an alternation of isomorphic generations.

Only one species is known.

Morphology and Reproduction:

Bory, 1823, p. 393; 1828, p. 206.
Hülsbruch, 1938, p. 474, figs. 1–5.
Kornmann, 1956, p. 259–272, figs. 1–7.
Papenfuss, 1960, p. 311.
Bliding, 1963, p. 20–23, figs. 5, 6.

Percursaria percursa (C. Agardh) Rosenvinge, 1893, p. 963.
Pl. 17, fig. D.

Thallus usually unbranched, several centimetres long, pale green in colour, frequently entangled in floating masses with *Enteromorpha* species. Mature filaments of one or two rows of cells (4 have also been reported), 10–20 (–25) μ wide; cells (10–) 20–25 (–30) μ long.

The chloroplast is laminate and parietal with two or three pyrenoids.

Reproduction as above for genus. Quadriflagellate zoospores are 4–5 μ in diameter and 7–8 μ long, have one chloroplast with a single pyrenoid and eyespot. Gametes are anteriorally biflagellate; male gametes are 2 μ in diameter and 6–7 μ long; and female gametes are 3–4 μ in diameter and 6–7 μ long.

References:

Agardh, 1817, p. 87 (as *Conferva percursa*); 1822, p. 424 (as *Ulva percursa*); 1824, p. 187 (as *Solenia percursa*).
Bory, 1828, p. 206.
Kützing, 1843, p. 246; 1849, p. 351; 1852, p. 32, pl. 99, fig. 3 (as *Schizogonium percursum*).
Harvey, 1849*a*, p. 215 (as *Enteromorpha percursa*).
Areschoug, 1850, p. 418 (as *Tetranema percursum*).
Kjellman, 1883*a*, p. 302; 1883*b*, p. 371 (as *Diplonema percursum*).
DeToni, 1889, p. 129 (as *Enteromorpha percursa*).

Rosenvinge, 1893, p. 963; 1894, p. 160.
Collins, Holden and Setchell, 1898, X (No. 469); 1902, XX (No. 968) (as *Enteromorpha percursa*).
Setchell and Gardner, 1903, p. 214 (as *Enteromorpha percursa*): 1920*a*, p. 274, pl. 14, fig. 6.
Collins, 1909*a*, p. 197 (as *Enteromorpha percursa*).
Hamel, 1928, p. 167.
Newton, 1931, p. 76, fig. 56.
Levring, 1935, p. 8; 1937, p. 22; 1960, p. 9.
Taylor, 1937, p. 59, pl. 1, fig. 8: 1957, p. 59, pl. 1, fig. 8.
Kylin, 1949, p. 16, fig. 9.
Papenfuss, 1950*b*, p. 179; 1960, p. 311.
Waern, 1952, p. 39.
Chapman, 1956, p. 429, fig. 80f (as *Enteromorpha percursa*).
Scagel, 1957, p. 45.
Bliding, 1963, p. 20–23, figs. 5, 6.

Habitat. In brackish pools in the upper intertidal zone and in lagoons.

Type Locality. Hofmansgave, Denmark (*Conferva percursa,* LD 13617).

Pacific Coast Distribution. Amaknak Island, Alaska, to San Francisco, California and in Chile.

Order *SCHIZOGONIALES* West, 1904, p. 56.

Prasiolales Fritsch, *in* West, 1927, p. 164.

There are both freshwater and marine species in this order; all are multicellular. As a result of division of the cells in one, two, or three planes, a variety of morphological structure is present in the order: the plants are filamentous with cells in an unbranched uniseriate or multiseriate row; or they may be monostromatic, flat, and blade-like in form; or they may be more or less solid parenchymatous cylinders. In the non-filamentous forms, the cells are usually arranged in regular groups. The cells are uninucleate, with a single axial, stellate chloroplast, and a central pyrenoid.

Vegetative reproduction occurs by fragmentation; non-motile mitospores (akinetes and aplanospores) are also reported. Where known, sexual reproduction is oogamous; the male gamete is anteriorally biflagellate.

Only one family, the Prasiolaceae, is represented in the local flora.

Family PRASIOLACEAE (Rabenhorst) Borzi *orth. mut.* Blackman and Tansley, 1902, p. 138.

Prasioleae Rabenhorst, 1868, p. 307.
Prasiolacee Borzi, 1895, p. 237.

The characteristics for the family are the same as given above for the order Schizogoniales.

KEY TO THE GENERA OF PRASIOLACEAE

1. Thallus a solid cylinder, usually constricted at intervals .... ROSENVINGIELLA, p. 69
1. Thallus otherwise 2
    2. Thallus an unbranched filament, except for short, attaching rhizoidal branches .... SCHIZOGONIUM, p. 65
    2. Thallus membranous, cells usually arranged in groups of four or multiples of four .... PRASIOLA, p. 66

There is some evidence indicating that three entities (*Rosenvingiella*, *Schizogonium*, and *Prasiola*) may be only different stages or phases in the development of the one genus, *Prasiola* (Børgesen, 1902; Silva, 1957*b*; Friedmann, 1959*b*; Bravo, 1962, 1965). There is other evidence to the contrary, at least as far as *Prasiola* and *Rosenvingiella* are concerned (Setchell and Gardner, 1920*a*; Waern, 1952). For descriptive purposes, the three genera are regarded for the present as separate entities, but the species may eventually all be considered within the one genus, *Prasiola*. On the other hand, since several species of each of these genera have been recognized, the nomenclatural fate of "species" of *Schizogonium* and *Rosenvingiella* and their precise relationship to the species of *Prasiola* recognized, cannot be satisfactorily determined until a more thorough study has been made. On a morphological basis, there is good evidence that "*Schizogonium*" is merely a stage in the development of *Prasiola* and *Rosenvingiella*: both, apparently, pass through a *Schizogonium*-like phase. However, the evidence for considering *Rosenvingiella* a further stage in the development of *Prasiola* is as yet inconclusive (*see* discussion on p. 69).

SCHIZOGONIUM Kützing, 1843, p. 245.

Thallus a uniseriate (occasionally two or three cells wide), usually unbranched filament: with one to several cells near the base or elsewhere becoming elongated and rhizoidal and providing an attachment; freshwater and marine species.

The cells are short and uninucleate; a single stellate, axial chloroplast containing a central pyrenoid is present in each cell.

Vegetative reproduction by fragmentation occurs; akinetes are also reported.

Sexual reproduction is unknown.

Morphology and Reproduction:

Kützing, 1843, p. 245–247, pl. 3, fig. VII, 4, 5.
Fritsch, 1935, p. 218, fig. 65, C, D.
Jao, 1937, p. 104, 105, pl. 12, figs. 1, 2.

Only one species is recorded for the area.

Schizogonium murale var. **uniseriatum** Jao, 1937, p. 104.
Pl. 12, figs. F–G.

Thallus filamentous, usually uniseriate (sometimes two or three cells wide); filaments 6–13 (–17) μ diameter, attached to the substratum by rhizoidal cells or filaments of cells which may or may not be branched; the rhizoids may be basal or may arise irregularly along the thallus.

The cells are 3–12 μ diameter, about 5 μ in length, and usually shorter than broad; cell wall thick and lamellose; single chloroplast stellate, axial, and with one pyrenoid.

Although Jao (1937, p. 104) described this as a new form and believed from culture studies that his material was quite unrelated to *Prasiola*, more recent evidence disputes this opinion. For descriptive purposes, this entity is retained here, but this form is most likely a stage in the development of *Rosenvingiella constricta* (Setchell and Gardner) Silva or *Prasiola meridionalis* Setchell and Gardner (*see* p. 66, 69).

References:

Jao, 1937, p. 104, pl. 12, figs. 1, 2.
Scagel, 1957, p. 46.

Habitat. On old wood in the upper intertidal zone.

Type Locality. Dinner Point, San Juan Island, Washington.

Pacific Coast Distribution. Southern British Columbia to Northern Washington.

PRASIOLA (C. Agardh) Meneghini, 1838, p. 360.
C. Agardh, 1822, p. 416 (as a tribe of *Ulva*)

There are both freshwater and marine species in this genus. Although some of the freshwater species attain a length and breadth of several centimetres, the marine species are all relatively small, blade-like forms. In the vegetative condition, the small, flat monostromatic blade is usually somewhat longer than broad, and it tapers toward the base to a narrow rhizoidal, multiseriate, or uniseriate attachment region. The cells are isodiametric in surface view, being longer in sectional view than in breadth; they are uninucleate with a stellate axial chloroplast containing a single pyrenoid. The division axis of cells in the vegetative condition rotates in such a way as to produce a very regular, rectangular pattern of cell arrangement.

Young vegetative thalli develop into spore-forming or gamete-producing plants. The basal portion of the adult thallus retains the vegetative diploid and monostromatic characteristics, and the distal portion of the thallus becomes fertile. Vegetative reproduction by fragmentation, by non-motile akinetes or aplanospores (mitospores), and sexual reproduction by oogamy with an anteriorly biflagellate sperm have been reported. The vegetative thallus is diploid and may develop from a germinating zygote or an akinete or an aplanospore.

In spore-producing plants (or regions) the cells remain diploid but undergo mitotic divisions to produce a (1–) 2–4-layered tissue in the fertile region. A gradual decomposition of the walls eventually releases aplanospores (mitospores) from these cells; each cell produces a single non-motile aplanospore. Akinetes are also reported.

In gamete-producing plants the cells of the proximal vegetative region remain diploid, but the cells of the distal, fertile region undergo meiotic divisions to produce a haploid fertile region. In this haploid, fertile region, a multilayered tissue of regular groups of cells in alternating light and dark patches results. The light regions, which may be up to 16 cells in thickness, contain undifferentiated male gametangia; a gradual decomposition of the walls of these cells eventually releases anteriorly biflagellate sperms; one sperm arises from each cell. The dark regions, which may be up to 8 cells in thickness, contain undifferentiated female gametangia; a gradual decomposition of the walls of these cells eventually releases larger, non-motile, female gametes or eggs; one egg arises from each cell. These light and dark regions are paired, each pair originating from the first meiotic division of a mother cell; according to Friedmann (1959*b*) each of these groups in the pair is to be regarded as homologous with a gametophyte, male and female respectively.

An occasional cell in the otherwise haploid, gamete-producing region of the thallus may remain diploid and vegetative, or may give rise to a diploid aplanospore.

Fertilization results in a posteriorly uniflagellate zygote having a brief free-swimming period before the zygote settles down to the substratum and germinates. On germination a uniseriate filamentous germling* results, the cells of which, after dividing in a second plane, produce a multicellular, flat, blade-like thallus.

Thick-walled aplanospores or zygotes, or both, may function as resting cells during adverse conditions, but generally they germinate immediately.

Morphology and Reproduction:

Carmichael, *in* Greville, 1826, pl. 226 (as *Bangia*); 1828, p. 42 (as *Ulva*).
Unger, 1833, p. 521–542, fig. 1, pl. 39 (as *Ulva terrestris*).
Meneghini, 1838, p. 360.
Jessen, 1848, p. 1–20, pls. 1, 2.
Lagerstedt, 1869, p. 1–42, figs. 1–4.
Schmitz, 1879, p. 345–377.
Inhäuser, 1889, p. 233–290, pls. 1, 10–13.
Borzi, 1895, p. 203–243, pls. 18–20.
Lagerheim, 1892, p. 366–374, pl. 20, figs. 1–23.
Børgesen, 1902, p. 482–487, fig. 99, a–o; 1908, p. 714, 715, fig. 152.
Reed, 1902, p. 160, pl. 15, fig. 7, pl. 16, figs. 8–13.
Wille, 1906*a*, p. 4–12, pl. 1, figs. 1–29.
Setchell and Gardner, 1920*a*, p. 275–279, pl. 10, figs. 1–3, pl. 17, fig. 3, pl. 19, fig. 8, pl. 20, figs. 1, 2; 1920*b*, p. 287–292, pl. 21, figs. 11–18, pl. 22, fig. 3, a–f, pl. 24, fig. 8, pl. 25, figs. 1, 2.
Sjöstedt, 1922, p. 37–45, figs. 1–31.
Hamel, 1928, p. 17, fig. 4, A–F.
Yabe, 1932, p. 39, 40, pl. 1, figs. 1–9.
Knebel, 1935, p. 1–120, figs. 1–32.
Hülsbruch, 1939, p. 263–267, figs. 1–3.
Yuasa, 1940, p. 196–198, figs. 1–3.
Uda, 1948, p. 33–37, 90–94, figs. 1–3.
Kylin, 1949, p. 31, fig. 32.
Fujiyama, 1949, p. 25–31, figs. 1, 2; 1955, p. 15–37, figs. 1–7, pls. 1–5.
Chadefaud, 1951, p. 113–116, figs. 1–4.
Waern, 1952, p. 41–44, fig. 19.
Lewin, 1955, p. 5–7, figs. 1–7.
Copeland, 1955, p. 138–140, fig. 1.
Drew and Friedmann, 1957, p. 557, 558, fig. 1.
Friedmann, 1959*a*, p. 124; 1959*b*, p. 571–594, figs. 1–6, pls. 1–4; 1960, p. 333–344, pls. 58–63; 1964, p. 186–190.
Manton and Friedmann, 1960, p. 443–462, pls. 92–104.
Bravo, 1962, p. 217–223, figs. 1–4; 1965, p. 177–194, figs. 1–22.
Cole and Akintobi, 1963, p. 661–668, figs. 1–17.

The criteria used by Setchell and Gardner (1920*a*, p. 276) to distinguish species of *Prasiola* recorded for the Pacific Coast are not entirely satisfactory. The distinctness of so-called "areoles" and the shape of the base of the plant are largely functions of the age of the plant or region of the thallus, and whether or not the plant is fertile. Likewise, the presence of a uniseriate or a multiseriate stipitate region is also variable within the same population. I have examined Gardner's specimen from Whidbey Island (UC 98157), identified as *P. calophylla* (Carmichael) Meneghini (1838, p. 360), and am of the opinion that it is probably a young stage of *P. meridionalis*. Jao's (1937) *P. linearis* is also more like *Rosenvingiella polyrhiza* (*see* p. 70), although it too may be a young, somewhat atypical stage of *P. meridionalis*. Since both of these plants (*P. calophylla* and *P. linearis*) were recorded from ecologically rather atypical regions for *P. meridionalis*, one might anticipate a rather anomalous appearance under extreme

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*This filamentous stage, according to some authors, is probably synonymous with *Schizogonium* and is apparently capable of producing akinetes under some conditions.

conditions. The distribution of *P. meridionalis* is not nearly so restricted as one is led to believe from the literature. Although often abundant on so-called "bird rocks" in exposed regions, it has a much more cosmopolitan distribution and is often confused with young plants of *Monostroma* and *Ulva*. It should be noted that an additional species, *P. borealis* Reed, has been recorded from Alaska (Reed, 1902, p. 160; Setchell and Gardner, 1920*a*, p. 277). There is some question whether this species can be held distinct from *P. meridionalis*, in consideration of the comments made above concerning the criteria used to distinguish species. I have compared plants of *Prasiola* from Adak Island, Alaska (UBC 7759) with *P. meridionalis* from the type locality (Neah Bay, Washington) from San Juan Island, Washington (UBC 11688), from Muir Creek, west coast of Vancouver Island, British Columbia (UBC 3498), and from Mussell Point, Monterey County, California (UC 696536), and find no consistent differences. If these two entities should, on further study, be found conspecific, *P. borealis* Reed (1902) will have priority over *P. meridionalis* (1920). The problem needs further study, particularly with reference to plants occurring in Alaska. For the present, only one somewhat polymorphic species, *Prasiola meridionalis* Setchell and Gardner, is recognized from this area.

Only one species is recognized in the local flora.

Prasiola meridionalis Setchell and Gardner, 1920*b*, p. 291.
Pl. 14, figs. A–G; pl. 15, figs. A–J; pl. 16, figs. A, B.

Thallus dirty green in colour, monostromatic, with a short, broad stipe, expanding rapidly in the mature plant into a broad blade, with a cordate base; up to 1.5 cm high and 1 cm broad. Attached by rhizoids developing at the base or along the margins of the blade. Several blades frequently arise from the same basal system. Blades more or less flat and regular in outline in early stages, but generally becoming curved, furled, or lobed at maturity. Blade 40–50 μ in thickness with cells 15–20 μ high and 5–8 μ broad in sectional view.

Cells uninucleate, chloroplast single, axial, and stellate with one pyrenoid. Cells 5–8 μ in diameter, cubical to rounded in surface view, at times in regular groups.

Vegetative reproduction by fragmentation; new blades apparently also regenerate from basal system of older plants; aplanospores and akinetes (presumably diploid mitospores) are also produced; akinetes spherical to ovoid, 20–40 μ in diameter; aplanospores usually about the same size or slightly smaller than the vegetative cells.

Sexual reproduction oogamous with anteriorly biflagellate sperm as described for the genus. The sperm is pyriform to fusiform in shape, up to 4 μ wide and 8 μ long (often smaller) with flagella up to 14 μ in length. The egg is round to ellipsoid, 3–5 μ in diameter and 4–7 μ in length. The zygote is round to ovoid and 3–6 μ in diameter.

References:

Meneghini, 1838, p. 360 (as *Ulva calophylla*).
Collins, 1909*a*, p. 219 (as *P. calophylla*).
Setchell and Gardner, 1920*a*, p. 278, pl. 29, fig. 2; p. 277 (as *P. calophylla*); 1920*b*, p. 291, pl. 25, fig. 2.
Jao, 1937, p. 105, pl. 13, figs. 5–7 (as *P. linearis*).
Smith, 1944, p. 53, pl. 2, figs. 10–15.
Doty, 1947, p. 22.
Rigg and Miller, 1949, p. 332.

Seagel, 1957, p. 47: p. 46 (as *P. calophylla* and *P. linearis*); 1961, Fasc. II, No. 34.
Bravo, 1962. p. 217; 1965, p. 177–194, figs. 1–22.
Cole and Akintobi, 1963, p. 661–668, figs. 1–17.

Habitat. In spray zone just above the intertidal zone, usually on exposed rocks (often bird rocks); occasionally in the upper intertidal zone.

Type Locality. Tomales Bay, Marin County, California.

Pacific Coast Distribution. Adak Island, Alaska, to Santa Cruz, California.

ROSENVINGIELLA Silva, 1957*b*, p. 41.

Gayella Rosenvinge, 1893, p. 936.

Thallus at first uniseriate and filamentous, eventually becoming multiseriate and terete, often moniliform with solid parenchymatous spheres of cells arising from cell divisions in three planes connected by single cells or short uniseriate filamentous segments; occasionally branched near base; sessile and attached by filamentous rhizoids. Growing in dense stands, at times intermingled with *Prasiola* and *Schizogonium* (*see* discussion on p. 65).

The cells are uninucleate; chloroplast single, axial, and stellate, with one pyrenoid.

Reproduction by non-motile, presumably diploid mitospores (aplanospores).

Sexual reproduction unknown, presumably as in *Prasiola*.

Morphology and Reproduction:

Gardner, 1917, p. 384–385, pl. 32, fig. 5; pl. 33, figs. 5–9 (as *Gayella*).
Setchell and Gardner, 1920*a*, p. 279–281, pl. 12, figs. 5–10 (as *Gayella*).
Hamel, 1928, p. 18, fig. 5A–D (as *Gayella*).
Smith, 1944, p. 54, pl. 2, figs. 8, 9 (as *Gayella*).
Waern, 1952, p. 44–47, figs. 20, 21 (as *Gayella*).
Silva, 1957*b*, p. 41.
Bravo, 1962, p. 217, figs. 1–4; 1965, p. 177–194, figs. 1–22.

Only one species is recorded in the local flora (*see* discussion on p. 70).

Rosenvingiella constricta (Setchell and Gardner) Silva, 1957*b*, p. 41.
Pl. 13, figs. A–F.

Thallus dark green in colour, 1–5 mm high, a uniseriate filament 15–20 μ in diameter near the base and attached by rhizoidal cells; occasionally branched in uniseriate region. Multiseriate above, except for single cells or a few cells in a uniseriate segment at fairly regular intervals, giving the thallus a constricted appearance. Thallus 100–175 μ in diameter at widest point.

Cells in basal uniseriate region 10–15 μ in diameter and about 5 μ in length; in upper multiseriate portion smaller and more or less isodiametric. Chloroplast single, stellate, occupying almost the entire cell, with one pyrenoid.

Reproduction unknown.*

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*According to a recent paper by Bravo (1965), oogamous sexual reproduction occurs in this plant similar to that described in *Prasiola* (*see* p. 66); and *Rosenvingiella constricta* is considered to be a form of *Prasiola meridionalis* that develops under certain conditions.

References:

Gardner, 1917, p. 384, pl. 33, figs. 5–9, pl. 32, fig. 5 (as *Gayella constricta*).
Collins, 1918, p. 57 (as *Gayella constricta*).
Setchell and Gardner, 1920*a*, p. 280, pl. 12, figs. 5–10 (as *G. constricta*).
Smith, 1944, p. 54, pl. 2, figs. 8, 9 (as *G. constricta*).
Waern, 1952, p. 46, fig. 20, f–j (as *G. constricta*).
Scagel, 1957, p. 47.
Silva, 1957*b*, p. 41.

Habitat. In spray region just above the intertidal zone on exposed rocks.

Type Locality. Tomales Point, Marin County, California (UC 205701).

Pacific Coast Distribution. West Coast of Vancouver Island, British Columbia (Muir Point, UBC 3501), to Santa Cruz, California.

A much longer plant of *Rosenvingiella*, probably referable to *R. polyrhiza* (Rosenvinge) Silva (Rosenvinge, 1893, p. 937, fig. 45), from North Island in Bay of Islands, Adak Island, Alaska (UBC 7776) reaches a length of 1–3 cm. However, in addition to the greater length of the thallus, the material from Alaska differs from *R. constricta* in two respects: although in the distal portion the plant is multiseriate and parenchymatous, it is narrower (40–70 μ diameter), and it is generally not constricted at intervals. This could, perhaps, be a phase in the development of another species of *Prasiola*, if indeed *Rosenvingiella* and *Prasiola* are phases of the same entity. It has been suggested by Børgesen (1902) and others that *R. polyrhiza* (Rosenvinge) Silva is a phase in the development of *Prasiola crispa* (Lightfoot) Meneghini. However, *P. crispa* has never been recorded from the Pacific Coast of North America. Although three species of *Prasiola* (*P. calophylla, P. linearis,* and *P. meridionalis*) have been recorded from British Columbia and Washington, nothing comparable to the plants of *Rosenvingiella* from Adak Island has been seen in this area. However, Jao's *P. linearis* is very similar to the Alaska material studied and may, in fact, be *R. polyrhiza* (*see* discussion on p. 67). Almost invariably *P. meridionalis* and *R. constricta* occur intermingled. Although *R. constricta* was not found on Adak Island, specimens of *Prasiola* were encountered intermingled with *R. polyrhiza,* and these seem referable to *P. meridionalis*. A more intensive study of all the species recorded in the North Pacific and more critical comparison with the northern European entities are needed before this problem can be completely resolved.

Order *CLADOPHORALES* West, 1904, p. 56.

Both freshwater and marine species; some genera with both freshwater and marine species, others strictly freshwater, and still others strictly marine. The plants are filamentous with cells in a uniseriate row; filaments free or in some instances united in a network; unbranched or branched, usually with a basal lobed holdfast or rhizoidal attachment of septate filaments; attached or free-floating. Cells usually multinucleate, large, with a parietal reticulate chloroplast, or numerous small discoid chloroplasts; with one to several pyrenoids.

Vegetative reproduction by fragmentation may occur; motile (zoospores) and non-motile (akinetes and aplanospores) mitospores and meiospores are also produced; zoospores are biflagellate or quadriflagellate. Mitospores are produced in large numbers in the sporangium, which is a modified vegetative cell, and they are liberated through a single pore.

Sexual reproduction is isogamous or anisogamous and by biflagellate gametes; gametes are produced in large numbers in the gametangium, which is a modified vegetative cell, and they are liberated through a single pore.

In some instances there is an alternation of isomorphic generations, in which case the zygote develops immediately into a multicellular sporophyte; in others an alternation of heteromorphic generations occurs, in which the zygote develops into a single-celled *Codiolum*- or *Chlorochytrium*-like stage; and in still others the plants may be haploid, with the zygote being the only cell of the diploid phase. In the latter case, on germination the zygote produces motile meiospores (zoospores). In one species of *Cladophora* the plant is reported to be diploid with meiosis occurring at gametogenesis. There are both bisexual and unisexual species.

Only one family, the Cladophoraceae, is represented in the local flora.*

Family CLADOPHORACEAE (Hassall) DeToni, 1889, p. 264.
Cladophoreae Hassall, 1845, p. 213.

Thallus is a branched (rarely unbranched) uniseriate filament whose branches arise in more than one plane. Attachment is by a system of septate rhizoidal filaments, a lobed holdfast, or a basal, stolon-like attachment structure.

The cells are generally multinucleate with a parietal, reticulate chloroplast (which may become divided up into a number of discoid portions under some conditions) containing a few to many pyrenoids.

The type of life history is varied, even in some instances within the same genus. An alternation of isomorphic generations occurs in some species, with unisexual gametophytes. In other species there is an alternation of heteromorphic generations, and the zygote develops into a single-celled *Codiolum*-like sporophyte. In one species of *Cladophora* the plant is reported to be diploid with meiosis occurring at gametogenesis.

Vegetative reproduction by fragmentation occurs; reproduction also occurs by quadriflagellate zoospores and akinetes.

Sexual reproduction is isogamous or anisogamous, usually with anteriorly biflagellate gametes.

KEY TO THE GENERA OF CLADOPHORACEAE

1. Filaments usually unbranched, or at most with only short, simple rhizoidal branches 2
1. Filaments repeatedly branched 5
    2. Filaments slender, usually in tangled masses and free-floating 3
    2. Filaments generally coarse with quite large cells and sessile with one or more differentiated basal rhizoidal or holdfast cells 4
3. Filaments occasionally with short rhizoidal branches ..... RHIZOCLONIUM, p. 72
3. Filaments unbranched .... LOLA, p. 75
    4. Cells moderately large, rhizoids arising from several cells near the base; zoospores blunt at anterior end and tapering to an acute posterior end .... UROSPORA, p. 76
    4. Cells usually very large, rhizoids arising only from basal cell; generally forming a basal disc; zoospores not with an acute posterior end .... CHAETOMORPHA, p. 82

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*Jónsson (1959) has proposed a new family, the Acrosiphoniaceae, to receive the genera *Acrosiphonia* (=*Spongomorpha* according to some authors), *Spongomorpha*, and *Urospora*, primarily because of the alternation of heteromorphic generations demonstrated in species of these genera (Jónsson, 1962, 1963). This has not yet been widely accepted. As a result of their observations in *Cladophora rupestris* (*see* p. 72), Archer and Burrows (1960) feel that this criterion is not a sound one to support the creation of the Acrosiphoniaceae. However, some authors refer *Acrosiphonia*, *Spongomorpha*, and *Urospora* to a separate family (Acrosiphoniaceae) and order (Acrosiphoniales).

5. Filaments usually united in rope-like strands by means of short, branched or unbranched, spine-like and recurved branches or by rhizoidal filaments .... SPONGOMORPHA, p. 94
5. Filaments not united in rope-like strands by recurved branches or rhizoidal filaments .... CLADOPHORA, p. 85

This family has a number of anomalies which await clarification before a satisfactory treatment of the nomenclature at the generic as well as specific levels can be given. The life histories of several genera in the family have been found to have stages which are similar to, if not identical with, entities which have been known as different genera in completely different orders. The classical example is the *Urospora mirabilis* (gametophyte) and *Codiolum gregarium* (sporophyte) relationship, first described by Jorde (1933). But more recently it has been shown that *Spongomorpha coalita* (gametophyte) and *Codiolum petrocelidis* (sporophyte) are related (Fan, 1959); *Spongomorpha lanosa* (gametophyte) and *Chlorochytrium inclusum* (sporophyte) (Jónsson, 1959) are also apparently related; as are also *Acrosiphonia spinescens* (gametophyte) (= *Spongomorpha spinescens*) and *Codiolum petrocelidis* (sporophyte) (Jónsson, 1959). Archer and Burrows (1960) have also found a *Codiolum* phase in *Cladophora rupestris*, although they state that it may not be an obligate phase. This latter observation, as well as the general character of the *Codiolum* and *Chlorochytrium* phases, suggests that these unicellular "genera" may, in fact, be interpreted simply as zygotes which, unlike their freshwater counterparts in the Cladophoraceae, never develop as thick-walled resting structures. They may develop immediately, or they may become somewhat amorphous (*Codiolum*-like or *Chlorochytrium*-like) cells which eventually germinate to produce zoospores (meiospores). However, the site of meiosis in this alternation of apparently heteromorphic generations has still not been established in all instances.

RHIZOCLONIUM Kützing, 1843, p. 261.

Thallus a uniseriate filament with short, simple, rhizoidal branches; generally forming intertwined masses of filaments in extensive mats on mud or other substrata, entangled with or growing on other algae, or free-floating.

Cells multinucleate (rarely uninucleate except when young) with a parietal reticulate chloroplast having a few to several pyrenoids.

Reproduction occurs by quadriflagellate zoospores (probably meiospores) which are produced in unmodified cells in large numbers and liberated through a lateral pore in the cell wall; akinetes and biflagellate zoospores have also been reported.

There is apparently an alternation of isomorphic generations. Sexual reproduction occurs by biflagellate isogametes, and the zygote develops immediately into the sporophyte.

The characteristics upon which specific diagnoses have been based in this genus relate chiefly to cell size. Until such time as the genus has been studied more carefully from an ecological point of view on this Coast, a satisfactory treatment cannot be given. The species concept adopted here is based in part on Koster's (1955) delimitation of species and review of nomenclature; two species are recognized in this area.

Morphology and Reproduction:

Kützing, 1843, p. 261.
Wille, 1901, p. 34–41, pls. III, IV.
Carter, 1919, p. 467–477, figs. 1, 2, pl. 27.
Hamel, 1928, p. 114–122, fig. 36, b–j.
Waern, 1952, p. 71–73.
Koster, 1955, p. 335–357, 5 figs., 5 tables.
Bliding, 1957, p. 271–275, figs. 1–3.
Sinha, 1958, p. 24–26, table 1.

Key to Species of Rhizoclonium

1. Filaments with or without rhizoidal branches (non-septate or with a few cells); cells 18–48 μ in diameter, usually one or two times as long as broad .... *R. riparium*, p. 74
1. Filaments usually without rhizoidal branches (rarely with short non-septate rhizoids); cells 10–21 μ in diameter and usually one or two times as long as broad .... *R. implexum*, p. 73

Rhizoclonium implexum (Dillwyn) Kützing, 1845, p. 206.
Pl. 33, figs. A, B.

Plants forming yellowish green mats of filaments entangled with other algae or free-floating in tide pools; filaments uniseriate, simple, rarely with non-septate rhizoidal branches (when present only as a prolongation of cells of the uniseriate axis); cells (8–) 14–15 (–21) μ in diameter and 1.5–3 (–8) times as long as broad (usually about 40 μ in length). There is a parietal, reticulate chloroplast with six to eight pyrenoids in the mature cell; cells are multinucleate with usually one to four nuclei to the cell.

The fertile cells become swollen and almost all cells in the filament become fertile at the same time; quadriflagellate zoospores (probably meiospores) are liberated through a lateral pore in the wall of the sporangium, zoospores are 12.5–16.8 μ in length with flagella 11–12 μ in length; an eyespot and one to three pyrenoids are present in a well-developed chloroplast. Apparently there is an alternation of isomorphic generations. The zoospores germinate to produce filamentous gametophytes. Terminally biflagellate isogametes are produced; gametes are 9.1–10.5 μ long and 4.0–5.1 μ broad with an eyespot and a small chloroplast containing one pyrenoid. The zygote germinates immediately following its formation.

References:

Dillwyn, 1809, p. 46, pl. B (as *Conferva implexa*).
Kützing, 1845, p. 206.
Harvey, 1849*a*, p. 209 (as *Conferva implexa*); 1871, pl. LIV, B (as *Conferva implexa*).
DeToni, 1889, p. 280 (as *R. tortuosum*).
Stockmayer, 1890, p. 582 (as *R. kerneri*).
Rosenvinge, 1893, p. 915, fig. 34 (as *R. riparium* var. *implexum*).
Collins, Holden and Setchell, 1897, VI (No. 266); 1902, XX (No. 976) (as *R. riparium* var. *implexum*); 1899, XIII (No. 623) (as *R. kerneri*).
Saunders, 1901, p. 414 (as *R. riparium* var. *implexum*).
Wille, 1901, p. 40, pl. IV, figs. 158–168 (as *R. kerneri*).
Setchell and Gardner, 1903, p. 222 (as *R. riparium* f. *implexum*); 1920*a*, p. 183; p. 185 (as *R. kerneri*).
Collins, 1909*a*, p. 328 (as *R. riparium* var. *implexum*); p. 329 (as *R. kerneri*); 1913, p. 103 (as *R. riparium* var. *implexum*); p. 103 (as *R. kerneri*).
Newton, 1931, p. 93.
Hamel, 1928, p. 116, fig. 36, b–e (as *R. kochianum*).
Levring, 1937, p. 31.
Smith, 1944, p. 62, pl. 8, fig. 3 (in part).
Doty, 1947, p. 26.
Kylin, 1949, p. 50 (as *R. kochianum*).
Koster, 1955, p. 335, fig. 2.
Chapman, 1956, p. 468, fig. 125II (as *R. kerneri*), p. 463, fig. 124III (as *Lola implexa*).
Bliding, 1957, p. 271, figs. 1, 2 (as *R. kochianum*).
Scagel, 1957, p. 47; p. 48 (as *R. kerneri*).

Habitat. On mud, sand, or pebbles in the intertidal zone, attached to or entangled with other algae, or free-floating in loose masses in tide pools.

Type Locality. Ireland, probably Bantry Bay (K, *Conferva implexa*).

Pacific Coast Distribution. St. Michael Island, Alaska, to Mexico, and in the Galapagos Islands.

Rhizoclonium riparium (Roth) Harvey, 1849*a*, p. 238.
Pl. 32, figs. A–E.

Plants forming dark green to pale yellowish green, entangled masses of uniseriate filaments up to 35 cm long; sometimes twisted or contorted; often unbranched, sometimes with a few main branches, usually with numerous short, tapering, irregular rhizoidal branches which may be non-septate or composed of two to five cells; rhizoidal branches sometimes forked at the distal end. Filaments are (18–) 25–35 (–70) μ in diameter with cells one to three (to six) times as long as broad, usually about (25–) 30–40 μ in length; with wall 2–3 μ thick and lamellose.

There is a single chloroplast in the cell; the chloroplast is parietal, coarsely reticulate, with 10 to 12 (–24) pyrenoids which are 2–3 μ in diameter. The cells are multinucleate when mature with three to five nuclei in the cell; the nuclei are 4–5 μ in diameter.

Quadriflagellate zoospores (probably meiospores), 14.1–18.0 μ long, are liberated through a lateral pore from undifferentiated intercalary cells (sporangia). Terminally biflagellate gametes, 11.5–13.2 μ long are produced; syngamy and germination of the zygote have been observed. Apparently there is an alternation of isomorphic generations.

Koster (1955) recognizes two varieties of this species, the typical one, *R. riparium* (Roth) Harvey var. *riparium* and *R. riparium* (Roth) Harvey var. *validum* Foslie (= *R. tortuosum* (Dillwyn) Kützing). The chief distinction used to separate these two varieties is cell size. The cells of *R. riparium* var. *riparium* are said to be (18–) 20–30 (–33) μ in diameter, and the filaments usually have abundant short, tapering rhizoidal branches with one to five cells; whereas the cells of *R. riparium* var. *validum* are 30–48 (–70) μ in diameter, rhizoidal branches are rare and, when present, without septa. According to these criteria both entities occur in this area, with the Pacific Coast distribution of *R. riparium* var. *riparium* recorded from Unalaska Island, Alaska, to Southern California and the Galapagos Islands; and of *R. riparium* var. *validum* (= *R. tortuosum*) from Kodiak Bay, Alaska, to Carmel, California. The type locality of the latter entity is Finmarken, Norway. However, these distinctions are scarcely tenable, and the variations encountered appear to be largely a result of ecological conditions; hence, only one variety (*R. riparium* var. *riparium*) is recognized in this treatment, and the concept of this variety is broadened to encompass all the local plants as well as those formerly (Scagel, 1957) included as *R. tortuosum* (= *R. riparium* var. *validum* according to Koster (1955)). It has also been suggested (Doty, 1947) that *R. implexum* may be nothing more than a form of the same species (*R. riparium*).

References:

Roth, 1806, p. 216 (as *Conferva riparia*).
Dillwyn, 1809, p. 69, pl. E (as *Conferva riparia*); p. 46, pl. 46 (as *C. tortuosa*).
Agardh, 1824, p. 106 (as *Conferva riparia*); p. 98 (as *C. tortuosa*).
Kützing, 1845, p. 205 (as *Rhizoclonium tortuosum*); 1849, p. 376 (as *Chaetomorpha tortuosa*).

Harvey, 1849*a*, p. 206, pl. 24, fig. F, 1, 2; p. 208, pl. XXIV, fig. E, 1, 2; 1849*b*, p. 238 (as *Conferva tortuosa*); 1858, p. 92; p. 88, pl. XLVI, fig. B (as *Chaetomorpha tortuosa*); 1871, pl. CCXXXVIII; pl. LIV, A (as *Conferva tortuosa*).
Kjellman, 1883*a*, p. 311.
Hauck, 1885, p. 443, fig. 194 (also as *R. tortuosa*).
DeToni, 1889, p. 278; p. 266 (as *Chaetomorpha tortuosa*).
Stockmayer, 1890, p. 580–583, figs. 5–7, 12–17 (as *R. hieroglyphicum*).
Rosenvinge, 1893, p. 913, fig. 32 (as *R. riparium* var. *polyrhizum*), p. 915, fig. 33 (as *R. riparium* var. *validum*).
Collins, Holden and Setchell, 1895, I (No. 24); 1911, XXXV (No. 1734); 1895, I (No. 23) (as *R. tortuosum*).
Wille, 1901, p. 35, pl. III, figs. 136, 137; pl. IV, figs. 138–142, 148–157.
Setchell and Gardner, 1903, p. 223 (as *R. tortuosum*); 1920*a*, p. 182; p. 185 (as *R. tortuosum*).
Collins, 1909*a*, p. 327 (as *R. riparium* var. *polyrhizum*); p. 328 (as *R. tortuosum*); 1913, p. 103 (as *R. riparium* var. *polyrhizum*).
Newton, 1931, p. 94, fig. 61.
Hamel, 1928, p. 115, fig. 36, f–j.
Levring, 1935, p. 13; 1937, p. 31.
Taylor, 1937, p. 83, pl. 1, fig. 3 (also as *R. tortuosum*); 1957, p. 81, pl. 1, fig. 3 (also as *R. riparium* var. *polyrhizum*); p. 80 (as *R. tortuosum*).
Nagai, 1940, p. 27 (as *R. tortuosum*).
Smith, 1944, p. 63, pl. 7, fig. 4; p. 62 (as *R. implexum* and *R. tortuosum*).
Sanborn and Doty, 1947, p. 26 (also as *R. tortuosum*).
Doty, 1947, p. 25 (also as *R. tortuosum*).
Hollenberg, 1948, p. 155.
Kylin, 1949, p. 50, fig. 51.
Waern, 1952, p. 71.
Tokida, 1954, p. 35 (as *R. tortuosum*).
Koster, 1955, p. 335, fig. 1; p. 342 (as *R. riparium* var. *validum*).
Chapman, 1956, p. 467, fig. 124I.
Scagel, 1957, p. 48; p. 49 (as *R. tortuosum*).
Bliding, 1957, p. 274, fig. 3.
Levring, 1960, p. 11 (also as *R. tortuosum*).

Habitat. In skein-like masses on various substrata, including clay banks and other algae, in the middle and upper intertidal zones.

Type Locality. Norderney Island, Germany (Lectotype (K) *Conferva riparia*).

Pacific Coast Distribution. Unalaska Island, Alaska, to Southern California, and in the Galapagos Islands and Chile.

LOLA A. and G. Hamel, 1929, p. 1094.

Plant an unbranched, uniseriate filament, attached by simple, non-septate rhizoids, or free-floating in dense mats; cells multinucleate, with a reticulate chloroplast and numerous pyrenoids.

Sexual reproduction by anisogamous, biflagellate gametes; reproduction by zoospores; other life-history details unknown.

Morphology and Reproduction:
Gardner, 1919, p. 492, 493, pl. 42, fig. 5.
Setchell and Gardner, 1920*a*, p. 185, pl. 9, fig. 5.
Hamel and Hamel, 1929, p. 1094–1096.
Hamel, 1928, p. 118–123, fig. 37, 1–8.
Christensen, 1957, p. 42, 43.

Lola lubrica (Setchell and Gardner) A. and G. Hamel, 1929, p. 1094.
Pl. 32, figs. F, G.

Plant pale green, often distinctly yellowish, comprising a straight, unbranched, uniseriate, cylindrical filament, 30–50 cm long, attached sometimes by short undifferentiated, non-septate rhizoids; flaccid and lubricous; often occurring in dense mats, free-floating or entangled with other algae. The cells are one to five times longer than broad, generally 35–60 μ in diameter and (65–) 125–175 (–230) μ in length when mature; the walls are about 2 μ thick and are delicately laminated. There is a parietal reticulate or perforate chloroplast which fills the cell and contains many (50 or more) pyrenoids about 5 μ in diameter. The cells are multinucleate with 10 to 12 (–16) nuclei in larger cells; the nuclei are 8–10 μ in diameter.

Biflagellate, anisogamous gametes have been reported; the female gamete is 4–8 μ long, the male 2–3 μ long. Zoospores are unknown and other details concerning life history are apparently unknown.

References:

Gardner, 1919, p. 492, pl. 42, fig. 5 (as *Rhizoclonium lubricum*).
Collins, Holden and Setchell, 1919, XLVI (No. 2289) (as *Rhizoclonium lubricum*).
Setchell and Gardner, 1920*a*, p. 185, pl. 9, fig. 5, a, b (as *Rhizoclonium lubricum*).
Hamel and Hamel, 1929, p. 1094.
Hamel, 1928, p. 118, fig. 37, 1–5.
Doty, 1947, p. 26 (as *Rhizoclonium lubricum*).
Scagel, 1957, p. 49.
Christensen, 1957, p. 42.
Dawson, 1961, p. 376.

Habitat. On mud flats in the intertidal zone.

Type Locality. Oakland, California (*Rhizoclonium lubricum*, UC 205694, type).

Pacific Coast Distribution. Northern Washington to Costa Rica.

The genus *Lola* has been considered of questionable validity, and the species referred to it have been regarded as species of *Rhizoclonium* by some authors. Doty (1947) has suggested also that *Lola lubrica* (=*Rhizoclonium lubricum*) may be a form of *R. riparium* (Roth) Harvey. But Christensen (1957) has presented recent observations which dispute this, and he regards it as a distinct entity (although referable to *Rhizoclonium*). However, Phinney (VIII, 1945) has annotated the type specimen as "young rapidly growing *Chaetomorpha tortuosa* (Dillw.) Kütz." Until the complex is better known, particularly in regard to reproduction and life-history details, this question cannot be pursued further.

UROSPORA Areschoug,[*] 1866, p. 15, *nom. cons.*

Thallus a uniseriate, unbranched filament; attached by a holdfast formed by rhizoidal non-septate filaments from several of the basal cells of the thallus; cell division intercalary. Plants generally occurring in dense tufts or stands.

The vegetative cells contain a few to several nuclei, a single parietal chloroplast, which is usually reticulate, perforate, or fenestrate, with few to many pyrenoids. All cells except those near the base are capable of becoming fertile and remain undifferentiated, although frequently becoming quite swollen.

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[*] In a recent paper Kornmann (1965) places *Urospora* in a new order, Codiolales.

Vegetative reproduction occurs by fragmentation; reproduction also occurs by distinctive quadriflagellate zoospores (probably mitospores), which are blunt at the anterior end and taper to an acute posterior end (biflagellate zoospores have also been reported but these are questionable); aplanospores and akinetes are also reported; zoospores are produced in large numbers and liberated from a single lateral pore in the cell wall.

On the basis of present information it would appear that there is an alternation of heteromorphic generations, with the *Urospora* phase being the haploid gametophyte and a *Codiolum* phase being the diploid sporophyte generation (*see also* discussion on p. 72).

Sexual reproduction from the *Urospora* phase by biflagellate isogametes or anisogametes has been reported from cells of the same filament and at the same time as quadriflagellate zoospores are being produced from other cells. The plants are apparently unisexual. Parthenogenetic development of the female gamete has also been reported.

Morphology and Reproduction:

Areschoug, 1866, p. 15, pl. III, figs. 1–8.
Hagem, 1908, p. 289, 299, pl. 1, figs. 1–10.
Frye and Zeller, 1915, p. 7–13, figs. 1–20.
Hart, 1928, p. 355–375, pl. 22.
Hamel, 1928, p. 126, 131, fig. 39, e–g.
Printz, 1927, p. 280; 1932, p. 273–287, pls. I, II.
Jorde, 1933, p. 1–19, figs. 1–5, pl. I.
Jónsson, 1958, p. 325–328, figs. 1–14; 1959, p. 1565–1567.
Fan, 1959, p. 1–12, figs. 1–41.
Kornmann, 1961*a*, p. 42–57, figs. 1–9; 1961*b*, p. 252–259, figs. 1–5; 1963*b*, p. 60–68, fig. 1; 1965, p. 163–172, fig. 3.
Hanic, 1965, p. 1–152, figs. 1–40.

The whole matter of reproduction, especially the nature of the gametes, life history, and the *Urospora-Codiolum* relationship, needs to be thoroughly investigated both morphologically and cytologically (*see also* discussion on p. 106). There have been observations on the development of several species of *Urospora*, but none of these investigations has been sufficiently complete to provide a satisfactory answer to the problem. Jorde (1933) and others (Printz, 1932; Hart, 1928) have obtained dwarf plants in culture from two different sizes of *Urospora* quadriflagellate zoospores. These plantlets, in turn, produced zoospores which ultimately gave rise to *Urospora* filaments. These dwarf stages may be cultural abnormalities. However, it is also possible that the *Codiolum* phase is not necessarily an obligate one. One can interpret the *Codiolum* phase as nothing more than a zygote (if meiosis occurs when this stage produces its quadriflagellate zoospores). In some species, at least, the quadriflagellate zoospores may germinate directly and repeatedly to produce consecutive *Urospora* phases; hence, they may be comparable to what Bliding (1933, 1948) has referred to in certain species of *Enteromorpha* as "neutral spores" (mitospores). If, as in some species of *Enteromorpha*, meiospores as well as mitospores should be produced by *Urospora* or a *Urospora*-like stage, one would have something approaching an alternation of isomorphic generations. This whole picture is further complicated by Hamel's (1931) report in *Urospora speciosa* (Carm.) Leblond of biflagellate zoospores, which are morphologically (except for size) apparently like the distinctive quadriflagellate zoospores typical of the *Urospora* plant; and by Printz's (1932) report of pyriform biflagellate gametes, morphologically unlike the distinctive posteriorly pointed quadriflagellate zoospores. Quadriflagellate gametes (Frye and Zeller, 1915) have also been reported in

Urospora, although this report is obviously questionable and most likely an error in interpretation. The incompleteness of the descriptions and the fragmentary illustrations with which several authors have illustrated the motile stages produced by both *Urospora* and *Codiolum* phases further confuse the reader. It is known from Kuckuck's observations (1896) and assumed by Fan (1959) that *Codiolum petrocelidis* produces quadriflagellate zoospores which do not have the morphological features found in the quadriflagellate zoospores of *Urospora*. However, Fan did not observe the free-swimming zoospores in *Codiolum petrocelidis*, nor did he determine the number of flagella present. On the other hand, in a local species of *Codiolum* (*see also* p. 106), typical *Urospora*-like quadriflagellate zoospores (probably meiospores) have been observed, and these germinated to produce filamentous *Urospora*-like thalli.

Key to Species of Urospora

1. Vegetative cells cylindrical; zoosporangia only slightly swollen and usually not over 100 μ in diameter; usually with extramatrical rhizoidal non-septate filaments .... *U. mirabilis*, p. 78
1. Zoosporangia usually quite swollen and over 100 μ in diameter; usually with intramatrical rhizoidal non-septate filaments 2
    2. Zoosporangia swollen, spherical, or slightly elongate, usually 1–3 mm in diameter .... *U. vancouveriana*, p. 80
    2. Zoosporangia swollen (sometimes only slightly), spherical to slightly elongate, 200–700 (–1000) μ in diameter .... *U. wormskjoldii*, p. 81

In delimiting species of *Urospora* on this Coast, it seems to me that Setchell and Gardner (1920*a*) have placed undue emphasis on the cell size and shape, and degree of perforation of the chloroplast. This seems particularly inconsistent when (for example, in species of the closely related genus *Chaetomorpha*, in fact even in the same filament in the same species) as great or greater degree of variability has been encompassed within one taxon, as in *Chaetomorpha cannabina*. The emphasis on the character of the chloroplast(s) is also quite inconsistent with known variability in the family. Depending on circumstances, in the same species in certain of the Cladophoraceae, the chloroplast can be either reticulate or perforate, whereas under other circumstances it can be fragmented into a large number of small discoid chloroplasts. In *Urospora vancouveriana*, in the same filament the chloroplast may vary from one cell to the next in the degree of perforation. Until such time as a more careful study is made of the genus *Urospora* in the living condition, there appears to be no completely satisfactory solution to the taxonomic problem that exists. From morphological data now available and from ecological observations in the local area, it appears doubtful that one should recognize more than three species (and one might, with equal justification, question whether two of these—*U. vancouveriana* and *U. wormskjoldii*—are not merely extremes in size range within one variable species (*U. wormskjoldii*)). For the present, however, three species are recognized; this treatment follows only in part the species concept adopted by Setchell and Gardner (1920*a*); a number of species described for this Coast have been reduced to synonymy. As a result of recent studies by Hanic (1965) *Urospora speciosa* (Carm.) Leblond *ex* Hamel is recorded for the first time for this Coast; it is unusual in having uninucleate cells. Acuminate quadriflagellate zoospores ranging from 8–12 μ long and 3–4 μ wide were observed, but other features of its life history in this area are not known. The filaments are less than 30 μ wide and 2 mm long with a rhizoidal holdfast of 1–4 rhizoids. However, it is not yet certain whether this plant is distinct from the entity referred to in this paper as *U. mirabilis*. Hanic's studies, however, support the recognition of *U. vancouveriana* and *U. wormskjoldii* as two distinct species.

Urospora mirabilis Areschoug, 1866, p. 16.
Pl. 36, figs. A–D.

Thallus filamentous, simple, 1–10 (–20) cm tall, dark green in colour and firm in texture; filament attached by extramatrical, non-septate rhizoids arising from a few of the lower segments; rhizoids are usually simple, but sometimes forked near the distal end; occasionally more than one rhizoid arises from each of the basal cells.

The vegetative cells are mostly cylindrical, or very slightly constricted at the septa, (20–) 30–60 (–90) μ in diameter and 0.3–2.5 (–4) times as long as broad. Fertile cells are slightly swollen, barrel-shaped, or occasionally almost spherical, 50–100 (–130) μ in diameter, one to three times as long as broad. The chloroplast is a single, continuous, parietal band which varies from faintly perforate to conspicuously perforate or fenestrate; there are several relatively large pyrenoids present in the chloroplast. The cell walls are relatively thick and lamellose.

Quadriflagellate zoospores (5–) 8–10 μ in diameter at the blunt anterior end, about 30 μ long and tapering to a long posterior projection, with flagella about 15 μ long; produced in large numbers and liberated through a single median pore in the cell wall of the sporangium. Akinetes are also reported; aplanospores (usually fewer in number than zoospores in the sporangium) are often produced (particularly in old cultures); vegetative reproduction by fragmentation also occurs.

Sexual reproduction is by anisogamous biflagellate gametes which may be formed in gametangia on the same filament on which zoospores are formed; gametes produced in large numbers and liberated through a median pore in the wall of the gametangium. Most of the information relating to life history and reproduction for the genus *Urospora* (*see* p. 76) applies to this species (sometimes as *U. penicilliformis*), which has apparently been studied more fully than any other species.

References:

Roth, 1806, p. 271 (as *Conferva penicilliformis*).
Fries, 1835, p. 327 (as *Hormiscia penicilliformis*).
Harvey, 1858, p. 90 (as *Hormotrichum speciosum*); 1862, p. 177 (as *H. carmichaelii*).
Areschoug, 1866, p. 16, pl. III, figs. 1–8; 1874, p. 4, pl. 1, figs. 1–6 (as *U. penicilliformis*).
Kjellman, 1883*a*, p. 315 (as *U. penicilliformis*).
DeToni, 1889, p. 232 (as *U. penicilliformis*).
Wille, 1890, p. 116, fig. 77 (as *U. penicilliformis*).
Rosenvinge, 1893, p. 918 (as *U. mirabilis* var. *elongata*).
Collins, Holden and Setchell, 1895, I (No. 18) (as *Ulothrix isogona*); 1903, XXIII (No. 1125) (as *Urospora incrassata*).
Setchell and Gardner, 1903, p. 220 (in part as *U. penicilliformis*); 1920*a*, p. 191, pl. 9, fig. 4 (as *Hormiscia penicilliformis*).
Kylin, 1907, p. 18, 1949, p. 46 (as *U. penicilliformis*).
Hagem, 1908, p. 294, pl. 1, figs. 1–4.
Collins, 1909*a*, p. 368, pl. XV, fig. 133 (as *Hormiscia penicilliformis*); 1913, p. 105 (as *H. penicilliformis*); 1918, p. 86 (as *U. penicilliformis*).
Hamel, 1928, p. 127, fig. 39, e–g.
Levring, 1935, p. 12 (as *U. penicilliformis*); 1937, p. 30 (as *U. penicilliformis*).
Fritsch, 1935, p. 240, fig. 71, C, D (as *U. penicilliformis*).
Taylor, 1937, p. 78; 1957, p. 77 (as *Hormiscia penicilliformis*).
Smith, 1944, p. 64, pl. 6, figs. 2, 3 (as *U. penicilliformis*).
Doty, 1947, p. 27, pl. 7, fig. 4 (as *U. penicilliformis*).
Sanborn and Doty, 1947, p. 25 (as *U. penicilliformis*).
Waern, 1952, p. 64.
Silva, 1952, p. 270.
Tokida, 1954, p. 37 (as *Hormiscia penicilliformis*).

Chapman, 1956, p. 469, fig. 128 (as *Hormiscia penicilliformis*).
Scagel, 1957, p. 50 (as *U. penicilliformis*).

Habitat. On rocks and old wood in the upper intertidal zone, frequently exposed to surf.

Type Locality. North Sea.

Pacific Coast Distribution. Bering Sea to Southern California.

Rosenvinge (1893, p. 918, fig. 35) has described a variety of this species (*U. mirabilis* Areschoug var. *elongata* Rosenvinge) in which the cells are 20–30 (–40) μ in diameter in the vegetative condition, and 20–65 μ diameter in the fertile region; the cells are 2.5 to 6 times as long as broad. These proportions (particularly the length of cells) have not been encountered in local material and, since the plant as described by Rosenvinge is not known to the author, only the typical variety *U. mirabilis* Areschoug var. *mirabilis* is recognized in this area.

Urospora vancouveriana (Tilden) Setchell and Gardner, *in* Gardner, 1919, p. 494.
Pl. 33, fig. I; pl. 34, figs. D–F; pl. 35, figs. A–F.

Thallus filamentous, simple, clavate, soft, and slippery, dark green in colour, in tufts, up to 10–15 (–30) cm high, attached by intramatrical rhizoids which arise from lower 14–15 (–30) basal segments.

The cells are cylindrical near the base when young (or slightly constricted at the septa), 75–130 (–600) μ in diameter, often quadrate, 0.5 to 3 times as long as broad; soon becoming decidedly moniliform in the upper segments, usually almost spherical, 1440–1500 μ in diameter, but sometimes up to 3 mm or even larger when fertile. There is a single, parietal, unbroken, band-like chloroplast, which may be very slightly if at all perforate in mature cells or, particularly in cells near the base, rhizoidal cells, or newly formed cells, decidedly perforate or even fenestrate; with numerous pyrenoids. The cells contain numerous nuclei.

Zoospores are produced in large numbers and liberated through a median pore in the wall of the sporangium; they are negatively phototactic, quadriflagellate, 7–13 μ in diameter at the blunt anterior end, (25–) 36–47 μ long, tapering to a long, slender spine, with four flagella inserted at the anterior end on a short papilla; the flagella are 18–20 (–25) μ long; there is a single, conspicuous pyrenoid (occasionally 2) about 5 μ in diameter toward the posterior end of the cell and a single nucleus about 2.5 μ in diameter near the anterior end.

Early stages in germination of quadriflagellate zoospores have been observed in the local species; these zoospores initiated dwarf filamentous *Urospora*-like phases. The dwarf filaments produce biflagellate zoospores which are released in vesicles. The biflagellate zoospores produce a *Codiolum* stage on germination. Sexual reproduction has not been observed.

The criteria used to distinguish *Urospora wormskjoldii* and *U. vancouveriana* appear somewhat dubious. In so far as the size of mature cells (and zoosporangia) is concerned the distinctions are certainly not clear-cut. Setchell and Gardner (1920*a*) also emphasize the thin, slightly (if at all) perforate chloroplast of *U. vancouveriana* in contrast to *U. wormskjoldii*, which is described as having a coarsely reticulate annular band. According to my observations on the local entities, and comparison with material from the type localities for both species, the chloroplast can be quite variable. In fact, within the same filament of *U. vancouveriana* one can find all degrees from a conspicuously perforate, even fenestrate, condition near the base (or in newly divided cells) to a very inconspicuously and delicately perforate condition distally. The only other difference that seems to be significant is the generally larger cells, especially the non-rhizoidal segments near the base; in *U. vancouveriana* they appear to be consistently larger in diameter (and relatively shorter in length) than in *U. wormskjoldii* where they are usually considerably narrower. The mature and fertile cells also generally tend to be more spherical in *U. vancouveriana* than in *U. wormskjoldii.* However, Hanic's studies support recognizing two distinct species based on chromosome counts (*U. wormskjoldii*, $n=12$; *U. vancouveriana*, $n=9$).

References:

Tilden, 1900, IV (No. 381) (as *U. wormskjoldii* f. *vancouveriana*).
Setchell and Gardner, 1903, p. 221 (in part as *U. wormskioldii*); 1920*a*, p. 197 (as *Hormiscia vancouveriana*).
Gardner, 1919, p. 494 (as *Hormiscia vancouveriana*).
Scagel, 1957, p. 51.
Hanic, 1965, p. 1–152, figs. 1–40.

Habitat. On stones and shells in the lower intertidal zone.

Type Locality. Oak Bay, Vancouver Island, British Columbia.

Pacific Coast Distribution. Southern British Columbia to Northern Washington.

Urospora wormskjoldii (Mertens) Rosenvinge, 1893, p. 920.
Pl. 35, figs. G, H; pl. 36, figs. E–I.

Thallus filamentous, simple, clavate, lubricous, in tufts up to 24 cm high, bright green in colour, attached by 5–23 generally intramatrical rhizoids which arise from the lower 12–15 (–20) segments.

The cells are cylindrical or slightly constricted at the septa and slender near the base, (25–) 30–70 μ in diameter, gradually increasing in diameter distally to 120–300 μ in diameter in the upper portion; (0.5–) 2–4 (–10) times as long as broad; in the fertile region usually swollen and constricted at the septa, truncate, long, ellipsoidal, or spherical, and (80–) 500–675 (–1200) μ in diameter. Cell walls are often thick and lamellose. The chloroplast is a single, parietal, unbroken band, which may be solid or inconspicuously perforate at maturity, but when young may be reticulate to fenestrate; with numerous small pyrenoids.

Quadriflagellate zoospores, which are blunt at the anterior end and taper to a long projection at the posterior end, have been recorded in this species; the zoospores are 15–20 μ long and 5–7 μ wide. The species is anisogamous and male and female gametangia are formed on separate plants. Male gametes are spindle-shaped, and average 8 μ in length and 2.5 μ in width; female gametes are ovate when first released and average 14 μ in length and 4 μ in width.

References:

Mertens, *in* Hornemann, 1818, p. 6, pl. 1547 (as *Conferva wormskjoldia*).
Fries, 1835, p. 328 (as *Hormiscia wormskjoldii*).
Kützing, 1845, p. 205 (as *Hormotrichum wormskioldii*); 1849, p. 383 (as *H. wormskioldii*).
Harvey, 1858, p. 91 (as *Hormiscia wormskjoldii*).
DeToni, 1889, p. 277 (as *Chaetomorpha wormskjoldii*).

Rosenvinge, 1893, p. 920, figs. 36, 37.
Collins, Holden and Setchell, 1902, XIX (No. 915); 1915, XLI (No. 2237) (as *Hormiscia tetraciliata*).
Setchell and Gardner, 1903, p. 220; 1920*a*, p. 196 (as *Hormiscia wormskioldii*); p. 193 (as *H. tetraciliata*); p. 196, pl. 9, fig. 2 (as *H. sphaerulifera*); p. 195, pl. 9, fig. 3 (as *H. grandis*).
Kylin, 1907, p. 18 (as *Hormiscia grandis*); 1949, p. 47, fig. 49.
Hagem, 1908, p. 296, pl. 1, figs. 6–9, p. 298 (as *U. grandis*).
Collins, 1909*a*, p. 368; 1913, p. 105 (as *Hormiscia wormskioldii*); 1918, p. 86 (as *H. wormskjioldii* and *H. tetraciliata*).
Frye and Zeller, 1915, p. 9, pl. 2 (as *Hormiscia tetraciliata*).
Gardner, 1919, p. 493, pl. 42, fig. 2 (as *Hormiscia sphaerulifera*), p. 494, pl. 42, fig. 3 (as *H. grandis*).
Hart, 1928, p. 355, figs. 1–32 (as *Hormiscia wormskioldii*).
Hamel, 1928, p. 126, fig. 39, a–d.
Levring, 1935, p. 12.
Taylor, 1937, p. 79; 1957, p. 77 (as *Hormiscia wormskjoldii*).
Doty, 1947, p. 27, pl. 7, fig. 9; p. 26, pl. 7, figs. 1, 2 (as *U. grandis*).
Sanborn and Doty, 1947, p. 25.
Tokida, 1954, p. 38, pls. I, XII, fig. D (as *Hormiscia wormskioldii*).
Scagel, 1957, p. 51 (as *U. wormskioldii, U. tetraciliata*, and *U. sphaerulifera*), p. 50 (as *U. grandis*).
Hanic, 1965, p. 1–152, figs. 1–40.

Habitat. On rocks, shells, and old wood, and epiphytic on other algae in the intertidal and upper subtidal zones.

Type Locality. Godthaab, Greenland.

Pacific Coast Distribution. Unalaska Island, Alaska, to Southern California.

CHAETOMORPHA Kützing, 1845, p. 203, *nom. cons.*

Thallus a uniseriate filament, unbranched, solitary or aggregated in tufts, attached or free-floating; holdfast cell discoid or with non-septate rhizoidal filaments growing out from an elongate basal cell. The cells are multinucleate with a parietal reticulate chloroplast (at times breaking up into a large number of small discoid chloroplasts) with many pyrenoids.

Vegetative reproduction by fragmentation; reproduction also occurs by quadriflagellate zoospores (probably meiospores) which are produced in the sporangia in large numbers and liberated through a single lateral pore in the cell wall; the sporangia are undifferentiated cells; akinetes have also been reported.

Sexual reproduction is isogamous with many terminally biflagellate gametes arising from the gametangium, which is an undifferentiated cell.

So far as is known, there is an alternation of isomorphic generations.

Morphology and Reproduction:
Kützing, 1845, p. 203.
Hartmann, 1929, p. 485–490, fig. 1.
Feldmann, 1937, p. 67–73, figs. 17–19.
Smith, 1944, p. 55, 56, pl. 6, figs. 4, 5.
Sinha, 1958, p. 24–26, tables 1, 3.
Chihara, 1958*b*, p. 183–189, figs. 1–3.
Kessler, 1960, p. 114–124, figs. 1–14.

Key to Species of Chaetomorpha

1. Filaments less than 40 μ in diameter 2
1. Filaments more than 40 μ in diameter .... *C. cannabina*, p. 83
    2. Filaments less than 15 μ in diameter and less than 40 μ in length .... *C. recurva*, p. 84
    2. Filaments more than 15 μ in diameter and usually more than 100 μ in length .... *C. californica*, p. 83

Chaetomorpha californica Collins, *in* Collins, Holden and Setchell, 1900, XIV (No. 664).
Pl. 33, figs. C–E.

Thallus an erect slender filament up to 20 cm long; attached by an elongate basal holdfast cell 100–150 (–200) μ in length; holdfast cell discoid with short stout non-septate rhizoidal branches; straight or flexuous, with cells of almost uniform diameter throughout, 20–25 (–40) μ in diameter and one to three (to five) times as long as broad (usually 100–150 (–200) μ in length). The walls are distinctly lamellose. The cells are multinucleate with up to 10 (–15) nuclei to the cell. There are many small discoid chloroplasts and numerous pyrenoids present in each cell.

Reproduction and life-history details are unknown in this species, but presumably they are as described for the genus (*see* p. 82).

Habitat. In pools in the intertidal zone and in the subtidal zone to a depth of 5 fathoms; attached to rocks and shells.

Type Locality. La Jolla, California (*Chaetomorpha californica*).

Pacific Coast Distribution. Juan de Fuca Strait (RFS 801L, Hein Bank, Washington, growing epizoically, along with *Petrocelis*, on *Acmaea instabilis*), to Southern California.

The local record of this species is based on two collections from dredged samples in Juan de Fuca Strait; they are both rather small and young specimens but appear to fit the description of this entity quite well; none of the plants was more than 36 cells in length.

References:
Collins, Holden and Setchell, 1900, XIV (No. 664).
Collins, 1906, p. 106; 1909*a*, p. 325.
Setchell and Gardner, 1920*a*, p. 200.
Dawson, 1961, p. 376.

Chaetomorpha cannabina (Areschoug) Kjellman, 1889, p. 55.
Pl. 33, figs. F–H.

Thallus filamentous, simple, unattached; light green in colour. Filaments variable in size from plant to plant and from place to place in the same filament, 75–100 (–250) μ in diameter and three to eight times as long as broad (usually 200–450 (–600) μ in length); attachment region unknown. The cells are often slightly barrel-shaped, especially in region of filament where cells are larger in diameter; the chloroplast is indistinctly reticulate, or there are numerous small discoid chloroplasts; there are a large number of pyrenoids, and the cells contain numerous nuclei.

Details concerning reproduction and life history are apparently unknown for this species; presumably as described for the genus (*see* p. 82).

References:

Areschoug, 1840, ed. 1, No. 14; ed. 2, No. 135 (as *Conferva cannabina*); 1843, p. 268, pl. 9, fig. 9 (as *C. cannabina*); 1850, p. 433, pl. III, fig. F (as *C. cannabina*).
Ruprecht, 1851, p. 399 (as *Conferva tortuosa* var. *crassior*).
Kjellman, 1889, p. 55.
Saunders, 1901, p. 413.
Collins, Holden and Setchell, 1902, XIX (No. 916).
Setchell and Gardner, 1903, p. 221; 1920*a*, p. 204.
Collins, 1909*a*, p. 325.
Taylor, 1937, p. 80; 1957, p. 78.
Rigg and Miller, 1949, p. 332.
Scagel, 1957, p. 52.

Habitat. In tangled masses, often intertwined with other algae in pools, and on wood in the intertidal zone.

Type Locality. Sweden (UPS, *Conferva cannabina*).

Pacific Coast Distribution. Norton Sound, Alaska, to Northern Washington.

Chaetomorpha recurva *nom. nov.*
Pl. 33, figs. C–E.

Thallus composed of unbranched, regularly recurved, uniseriate filaments; growing in tufts, up to 2 cm high, epiphytic on various larger algae; filament attached by a small, discoid, lobed holdfast at the proximal end of a tapering holdfast cell; holdfast cell 5–7 (–10) μ in diameter, 18–30 μ long. The cells are 6–10 (–12) μ in diameter, 14–35 μ long, with thick lamellose walls; apical cell mucronate.

Zoospores are recorded; they are liberated through a lateral pore in the cell wall.

References:

Crouan, *in* Schramm and Mazé, 1865, p. 35; *in* Mazé and Schramm, 1870–1877, p. 51 (as to name *C. tenuissima* only).
DeToni, 1889, p. 276 (as to name *C. tenuissima* only).
Jao, 1937, p. 101, pl. XII, figs. 3–5 (as *C. tenuissima*).
Scagel, 1957, p. 52 (as *C. tenuissima*).

Habitat. Epiphytic on various other algae, including *Codium fragile, Platythamnion pectinatum, Acrochaetium rhizoideum,* and articulated coralline algae in the lower intertidal and upper subtidal zones.

Type Locality. Turn Island, San Juan Channel, Washington (Jao, 1275, *Chaetomorpha tenuissima*).

Pacific Coast Distribution. Northern Washington.

This species is very poorly known. The description and illustrations are from Jao (1937). Except for the rather shorter length of the thallus and smaller dimensions of cells, this entity appears rather like *Chaetomorpha californica* Collins. The new specific epithet has been proposed, since the name given by Jao for his new species is apparently a later homonym of *C. tenuissima* Crouan, in Schramm and Mazé (1865) and Mazé and Schramm (1870–1877). Jao's plant bears no relation to the Crouan specimen (No. 318, parasitic on *Gelidium*, BM), which is a much taller plant with cells having a larger diameter and greater length (about 20 μ diameter and 100 μ in length).

CLADOPHORA Kützing, 1843, p. 262, *nom. cons.*

Thallus a uniseriate filament, generally profusely but sometimes sparsely branched; different orders of branches usually differ in diameter and branching habit; attached by a rhizoidal system arising from the basal cells, or at times free-floating. Growth apical or restricted to subterminal cells in the filament. Branching is lateral, at times appearing as if dichotomously or trichotomously branched.

The cells are cylindrical or barrel-shaped and multinucleate; a single parietal chloroplast is present with many pyrenoids; the chloroplast may break up into a large number of small discoid chloroplasts; cell wall thick and frequently laminated.

Vegetative reproduction by fragmentation occurs. Terminal or subterminal cells of the filaments become fertile. Quadriflagellate (rarely biflagellate) pyriform zoospores (meiospores) are produced in large numbers in terminal or subterminal sporangia and are liberated through a lateral pore in the upper end of the cell.

Sexual reproduction is isogamous by pyriform biflagellate gametes; gametes are produced in large numbers in terminal or subterminal gametangia and released through a lateral pore in the upper end of the cell; gametes at times germinate parthenogenetically; plants are usually unisexual.

An alternation of isomorphic generations occurs in some species; in other species the multicellular phase is haploid with the zygote being the only diploid phase represented (or there may be a *Codiolum*-like diploid phase); and in still others it is diploid with meiosis occurring at gametogenesis.

Morphology and Reproduction:

Kützing, 1843, p. 262.
Collins, 1902, p. 111–127, pl. 36; 1909*b*, p. 17–20, pl. 78.
Carter, 1919, p. 467–478, figs. 1, 2, pl. XXVII.
Hamel, 1924, p. 168–174, 293–297, 458–461, figs. 1–6; 1925, p. 68–71, fig. 7; 1926, p. 43–76, figs. 8–20.
List, 1930, p. 453–481, figs. 1–4.
Føyn, 1929, p. 495–502, fig. 1, a–f; 1934*b*, p. 1–56, figs. 1–18, pls. 1–5.
Bliding, 1935, p. 57–60, figs. 1, 2; 1936, p. 527–536, figs. 1–3.
Schreiber, 1942, p. 414–417, table 2.
Waern, 1952, p. 75–84, fig. 31.
Schussnig, 1954, p. 287–322, figs. 1–22.
Söderström, 1955, p. 275–281, figs. 1–13; 1963, p. 1–147, figs. 1–125.
Sinha, 1958, p. 24–26, tables 1–3.
Archer and Burrows, 1960, p. 32.
Chihara, 1960*b*, p. 1–11, figs. 1–4.
Hoek, 1961, p. 59; 1964*a*, p. 89–98, figs. 1–10; 1964*b*, p. 43–52, figs. 1, 2.

The genus *Cladophora* comprises a cosmopolitan and extremely large and heterogeneous group of species which have both freshwater and marine representatives. The limits of most of these species are not set apart by very marked characteristics. Except for a few clear-cut entities, they are extremely difficult to distinguish on the basis of morphological criteria; in most respects the genus is in a most unsatisfactory taxonomic status. Recent work, particularly as a result of cultural studies, indicates the plasticity of certain entities in the genus and the need for more critical study of this group in the living condition in order to clarify taxonomic as well as life-history problems. Undoubtedly some of the species that have been described or recorded for this area, as well as elsewhere, will be reduced to synonymy when the genus is better understood. The synonymy amongst the older species is particularly complex and troublesome; and in some species several varieties have been described. However, few recent studies have been made on the Pacific Coast species. The treatment followed here is based in part on Collins' (1909*a*) concept of the genus, although no attempt has been made to consider separate varieties in those species for which diagnoses are given. Of the species recognized in this area a few are fairly clear-cut, but some entities are of questionable status. The relationships of a number of these species to those recorded in the North Atlantic and in Japan are also still uncertain.

Key to Species of Cladophora

1. Thallus low and procumbent, composed of sparingly branched filaments in hemispherical tufts or mats; main filaments 120–200 (–275) μ in diameter; branching in main axes dichotomous or trichotomous .... *C. trichotoma*, p. 93
1. Thallus erect, tufted or loosely spreading 2
  2. Filaments very sparsely branched, fairly uniform in diameter from one order of branching to the next; main filaments usually over 200 μ in diameter; cells usually three to four times as long as broad .... *C. hutchinsiae*, p. 90
  2. Filaments usually profusely branched, with orders of branching generally varying considerably in habit and sometimes in diameter from one order to the next; main filaments less than 200 μ in diameter 3
3. Filaments usually not over 30 μ in diameter .... *C. albida*, p. 86
3. Filaments usually over 30 μ in diameter 4
  4. Branching predominately pectinate in final orders, with branchlets usually several cells in length along the adaxial side of recurved axes .... *C. microcladioides*, p. 92
  4. Branching habit otherwise 5
5. Branching irregularly alternate, becoming secund in final orders with ultimate branchlets relatively long .... *C. gracilis*, p. 89
5. Branching otherwise 6
  6. Branching alternate or secund, sometimes recurved with short ultimate branchlets of only a few cells in length; flexuous .... *C. flexuosa*, p. 87
  6. Branching habit otherwise 7
7. Branchlets clustered at the tips .... *C. laetevirens*, p. 91
7. Branchlets not clustered at the tips 8
  8. Main filaments usually 60–80 μ in diameter; branchlets usually tapering to an acute or subacute apex .... *C. glaucescens*, p. 88
  8. Main filaments usually 100–150 μ in diameter; branchlets usually rounded and blunt at apex .... *C. stimpsonii*, p. 93

Cladophora albida (Hudson) Kützing, 1843, p. 267.*
Pl. 43, figs. A, B.

Thallus delicate, soft, pale green, dense and often matted, up to 10 cm high; filaments 20–30 μ in diameter, with cells four to five times as long as broad; branching of thallus more or less dichotomous below, irregular above, sometimes becoming unilateral, with long ultimate branchlets.

There is a single reticulate chloroplast with numerous pyrenoids.

Reproduction and life-history details are apparently unknown in the local plant; presumably they are as described for the genus (*see* p. 85) and as recorded in the European plant referred to this species. Quadriflagellate zoospores are 13.8 μ long and 6.4 μ wide. Biflagellate gametes are 8.5–10.7 μ long, 4.0–4.7 μ broad, with the flagella 14 μ long and with one pyrenoid and a single eyespot.

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*Varieties have been described in this species but are not distinguished in this treatment; only the one entity, *C. albida* var. *albida*, is recognized.

References:

Hudson, 1762, p. 595; 1778, p. 595 (as *Conferva albida*).
Dillwyn, 1809, p. 32, pl. E.
Kützing, 1843, p. 267; 1849, p. 400; 1852, p. 4, pl. 15, fig. 2.
Harvey, 1849*a*, p. 203; 1849, pl. 275; 1858, p. 80; 1871, pl. CCLXXV.
Hauck, 1885, p. 458.
DeToni, 1889, p. 325.
Collins, 1902, p. 119; 1909*a*, p. 336.
Collins, Holden and Setchell, 1905, XXV (No. 1227).
Setchell and Gardner, 1920*a*, p. 218.
Hamel, 1926, p. 66, fig. 17, B, C.
Newton, 1931, p. 86.
Bliding, 1936, p. 531, fig. 2 (as *C. albida* var. *refracta*).
Taylor, 1937, p. 86; 1957, p. 83.
Söderström, 1955, p. 275, figs. 1–10; 1963, p. 65–71, figs. 55–60, 62A.
Chapman, 1956, p. 453, fig. 108 (as *C. albida* var. *refracta*).
Scagel, 1957, p. 52.
Hoek, 1963, p. 94–110, figs. 241–243, 258–314; 1964*a*, p. 91–94, figs. 3–6.

Habitat. In the intertidal zone.

Type Locality. Torquay, England (*Conferva albida*).

Pacific Coast Distribution. Northern Washington to El Salvador.

Cladophora flexuosa (Griffiths) Harvey, 1851, p. 353.*
Pl. 43, fig. C; pl. 44, fig. A.

Thallus light green, erect, 5–10 (–20) cm high, profusely branched; flexuous; the filaments toward the base in the main axes are 100–130 μ in diameter and four to six times as long as broad; above the filaments are (50–) 80–90 μ in diameter and four to five times as long as broad; the ultimate ramuli are 40–45 μ in diameter and taper to a subacute apex. Branching of the thallus below is dichotomous or trichotomous; above branches are alternate or secund, sometimes recurved with short ultimate branchlets of a few cells in length. The walls are thick and lamellose. The thallus is attached to the substratum by non-septate or septate, simple or branched rhizoidal filaments arising from the basal cells of the filament.

There is a single, parietal, coarsely reticulate chloroplast with numerous pyrenoids; the cells are multinucleate.

Reproduction and life-history details are apparently unknown in the local plant, but they are presumably as described for the European plant referred to this species. There is an alternation of isomorphic generations. The zoospores are 21.5–24.5 μ long and 10.5–13.5 μ in diameter. Sexual reproduction is isogamous, and the gametes are 16.5–17.5 μ long and 9–12.5 μ in diameter.

References:

Griffiths, *in* Wyatt, 1833, No. 227 (as *Conferva flexuosa*).
Harvey, 1849*a*, p. 202; 1851, p. 353, pl. 353; 1858, p. 78; 1871, p. CCCLIII.
Hauck, 1885, p. 456.
DeToni, 1889, p. 311.
Collins, 1902, p. 121, pl. 36, fig. 7; 1909*a*, p. 339; 1913, p. 104.

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*Although varietal status has been recognized in this species by some authors, there seems little justification for such. The specimens observed in this area agree closely with the type and should therefore be regarded as *Cladophora flexuosa* (Griffiths) Harvey var. *flexuosa*.

Collins, Holden and Setchell, 1903, XXII (No. 1076); 1908, XXXI (No 1527); 1917, XLV (No. 2239).
Setchell and Gardner, 1903, p. 224; 1920*a*, p. 217.
Hamel, 1926, p. 62, fig. 16, C.
Newton, 1931, p. 85.
Taylor, 1937, p. 87; 1957, p. 85.
Smith, 1944, p. 60.
Scagel, 1957, p. 53.
Sinha, 1958, p. 24.
Söderström, 1963, p. 90–106, figs. 17, 21, 24, 25, 81–94.
Hoek, 1964*a*, p. 95.

Habitat. In rock pools in the lower intertidal zone.

Type Locality. Torquay Harbour, Devon, England (BM, K, TCD. *Conferva flexuosa* Griffiths).

Pacific Coast Distribution. Annette Island, Alaska, to Southern California (UBC 447L, Mukkaw Bay, Washington, 16 August 1955; UBC 874L, entrance Kyuquot Sound, west coast of Vancouver Island, 3 July 1958).

Cladophora glaucescens (Griffiths) Harvey, 1862, p. 176.
Pl. 44, figs. B, C; pl. 45, figs. A–C.

Thallus glaucous green, often yellowish green above, 5–10 (–40) cm tall, loosely tufted, soft; main axes elongate, much branched; ultimate branches long, erect, tapering at the apices to an obtuse end. The filaments toward the base in the main axes are 60–80 (–110) μ in diameter and above are 45–60 μ in diameter; ultimate branchlets are (20–) 25–30 (–40) μ in diameter. The segments are (two to) four to eight (to twelve) times as long as broad. Branching of filaments is alternate or sometimes secund; occasionally dichotomous or trichotomous in main axes below. The walls of the cells are thick and lamellose. The thallus is attached to the substratum by a few modified basal cells which become rhizoidal in nature, sometimes forming non-septate branches.

There is a single, parietal, reticulate chloroplast with numerous pyrenoids, and the cells are multinucleate.

Fertile segments are seriate, only slightly swollen, and at maturity have a discharge pore near the upper end of the cell. Other details relating to reproduction and life history of the local plant are unknown; presumably they are as described for the genus (*see* p. 85).[*]

References:

Griffiths, *in* Wyatt, 1833, No. 195.
Harvey, 1849*a*, p. 205; 1848, pl. 196; 1858, p. 77; 1862, p. 176; 1871, pl. CXCVI.
Kützing, 1854, p. 5, pl. 24, fig. 1.
Kjellman, 1883*a*, p. 308.
Hauck, 1885, p. 460.
DeToni, 1889, p. 320.
Collins, Holden and Setchell, 1901, XVII (No. 817).

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[*] Biflagellate zoospores are reported by Bliding (1936, p. 529) for this species in Europe; they are 15–22 μ long and 9–11 μ wide. However, Kylin (1949, p. 52) suggests these are probably parthenogenetically developing gametes.

Collins, 1902, p. 120, pl. 36, fig. 6; 1909*a*, p. 336; 1913, p. 103.
Setchell and Gardner, 1903, p. 224; 1920*a*, p. 219.
Yendo, 1916, p. 248.
Børgesen, 1925, p. 66.
Hamel, 1926, p. 64.
Newton, 1931, p. 85.
Levring, 1935, p. 15; 1937, p. 33.
Bliding, 1936, p. 529, fig. 1.
Taylor, 1937, p. 86; 1957, p. 84.
Kylin, 1949, p. 52, fig. 53.
Rigg and Miller, 1949, p. 332.
Tokida, 1954, p. 42.
Chapman, 1956, p. 452, fig. 107.
Scagel, 1957, p. 53.
Söderström, 1963, p. 79–90, figs. 69–79.

Habitat. In pools in the upper intertidal zone.

Type Locality. Tor Bay, Devon, England (BM, K, TCD, *Conferva glaucescens* Griffiths).

Pacific Coast Distribution. Entrance to Kyuquot Sound, west coast of Vancouver Island, British Columbia (UBC 874bL, 3 July 1958), to Oakland, California.

Cladophora gracilis (Griffiths) Kützing, 1845, p. 215.*
Pl. 43, fig. D; pl. 46, fig. A.

Thallus pale or greyish green, erect; filaments much branched, forming dense tufts. The filaments toward the base in the main axes are up to 100 (–160) μ in diameter and the cells are four or five (to six) times as long as broad; above the filaments are 40–60 μ in diameter and the cells are three to five times as long as broad; the ultimate branchlets are 25–30 (–40) μ in diameter. The walls are thick and lamellose. Branching of the thallus below is more or less dichotomous or trichotomous; above, it is irregularly alternate, becoming secund in the final orders with ultimate branchlets relatively long.

There is a single, parietal, reticulate chloroplast and numerous pyrenoids; the cells are multinucleate.

Reproduction and life-history details are unknown in the local plant but are presumably as described for the European plant referred to this species. There is an alternation of isomorphic generations. Quadriflagellate zoospores are 17.0 μ long and 8.7 μ in diameter. Sexual reproduction is isogamous, and the plants are unisexual; the gametes are 10.3 μ long and 5.3 μ in diameter.

References:

Griffiths, *in* Wyatt, 1833, No. 97.
Kützing, 1845, p. 215; 1849, p. 402 (as *C. vadorum*), p. 403; 1854, p. 4, pl. 20, fig. 1 (as *C. vadorum*).
Harvey, 1849*a*, p. 202; 1846, pl. 18; 1858, p. 80; 1871, pl. XVIII.
Kjellman, 1883*a*, p. 308.
Hauk, 1885, p. 457, fig. 195.
DeToni, 1889, p. 322.

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*Although varietal status has been recognized in this species by some authors, there seems little justification for such. The specimens observed in this area agree closely with the type and should, therefore, be regarded as *Cladophora gracilis* (Griffiths) Kützing var. *gracilis*.

Collins, Holden and Setchell, 1900, XV (No. 724); 1908, XXXI (No. 15[illegible]);
1908, XXXI (No. 1529).
Collins, 1902, p. 121, pl. 36, fig. 8; 1909*a*, p. 342.
Setchell and Gardner, 1920*a*, p. 216.
Hamel, 1926, p. 63, fig. 16, a.
Newton, 1931, p. 85.
Levring, 1935, p. 14; 1937, p. 33.
Bliding, 1936, p. 532.
Taylor, 1937, p. 89, pl. 5, figs. 1, 2, 6, 7; 1957, p. 86, pl. 5, fig. 2, pl. 6, figs
3, 4.
Doty, 1947, p. 23.
Kylin, 1949, p. 55, fig. 56.
Chapman, 1956, p. 454, fig. 110.
Scagel, 1957, p. 53.
Lund, 1959, p. 34.

Habitat. In shallow pools in the upper and middle intertidal zones.

Type Locality. Tor Bay, Devon, England (BM, K, *Conferva gracili*
Griffiths).

Pacific Coast Distribution. Sitka, Alaska, to Northern Washington. (UBC 348L, Port Renfrew, 15 May 1961).

Cladophora hutchinsiae (Dillwyn) Kützing, 1845, p. 210.*
Pl. 44, fig. D; pl. 45, fig. D; pl. 46, figs. B–D.

Thallus stiff and coarse, glaucous green, 5–10 (–40) cm high; filaments stout, sparingly branched, flexuous; with a few main axes (sometimes with a few dichotomous or trichotomous divisions below) bearing a few scattered, short, blunt, secund branchlets; main filaments 120–300 (–475) μ in diameter and two or three (to four) times as long as broad; distal branchlets 90–100 (–250) μ in diameter and one or two times as long as broad; filaments terminating in blunt rounded cells at the apices; filaments frequently constricted at the septa; walls thick and lamellose. The thallus is attached to the substratum by simple or branched, septate or non-septate rhizoidal filamentous outgrowths from the basal portion of the filament; rhizoids sometimes expanding at the tip to form a discoid holdfast structure.

There is a single, parietal, finely to coarsely perforate or reticulate chloroplast with numerous pyrenoids; the cells are multinucleate.

Life-history and reproductive details are apparently unknown in the local plant, but presumably are as described in the genus (*see* p. 85) and as described for the European plant referred to this species. The quadriflagellate zoospores are 13.5–15.5 μ long and 10.5–12.5 μ broad. The gametes are 10–11 μ long and 7–8 μ broad.

References:

Dillwyn, 1809, p. 65, pl. 109 (as *Conferva hutchinsiae*).
Agardh, 1824, p. 120 (as *Conferva distans*).

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*Although *Cladophora hutchinsiae* var. *distans* (C. Agardh) Kützing has been recorded on this Coast, some doubt concerning its presence has existed (*see* Setchell and Gardner, 1920*a*, p. 213). The plants referable to this species that I have observed, including specimens from the west coast of Vancouver Island and the north end of the Queen Charlotte Islands in British Columbia, have ranged throughout the dimensions given for both *C. hutchinsiae* (Dillwyn) Kützing var. *hutchinsiae* and *C. hutchinsiae* var. *distans*. Therefore, there does not appear to be any justification for considering separate varieties in the complex as it exists on this Coast. If a choice were to be made on the basis of this diagnosis, however, it would seem more logical to refer all these entities to *C. hutchinsiae* var. *distans*.

Kützing, 1845, p. 210 (as *C. hutchinsiae*); 1849, p. 391; p. 392 (as *C. hutchinsiae* var. *distans*); 1853, p. 25, pl. 87, fig. 1; p. 25, pl. 88, fig. 1 (as *C. diffusa*).
Harvey, 1849*a*, p. 200 (as *C. hutchinsiae*), p. 201 (as *C. hutchinsiae* var. *distans*); 1847, pl. 124; 1858, p. 83 (as *C. diffusa*); 1871, pl. CXXIV; pl. CXXX (as *C. diffusa*).
Hauck, 1885, p. 453 (also as *C. hutchinsiae* var. *distans*).
DeToni, 1889, p. 314; p. 315 (as *C. hutchinsiae* var. *distans*).
Collins, 1902, p. 126, pl. 36, fig. 14; 1909*a*, p. 345 (as *C. hutchinsiae*), p. 346 (as *C. hutchinsiae* var. *distans*); 1913, p. 104 (as *C. hutchinsiae* var. *distans*).
Setchell and Gardner, 1903, p. 228 (as *C. hutchinsiae* var. *distans*); 1920*a*, p. 213 (as *C. hutchinsiae* and *C. hutchinsiae* var. *distans*).
Hamel, 1924, p. 295–297, fig. 2A (also as *C. hutchinsiae* var. *distans*).
Newton, 1931, p. 82 (also as *C. hutchinsiae* var. *distans*).
Taylor, 1937, p. 91, 1957, p. 88 (also as *C. hutchinsiae* var. *distans*).
Scagel, 1957, p. 54 (also as *C. hutchinsiae* var. *distans*).
Sinha, 1958, p. 26.
Söderström, 1963, p. 126–132, figs. 118–123.
Hoek, 1963, p. 60–65, figs. 131–145; 1964*a*, p. 95, 96, figs. 7, 8.

Habitat. In the intertidal zone.

Type Locality. On the Atlantic Coast, probably at Bantry Bay, Ireland (BM, K, LD, *Conferva hutchinsiae*).

Pacific Coast Distribution. Queen Charlotte Islands, British Columbia (UBC 446L, Mazzaredo Islands, north end of Queen Charlotte Islands, 26 July 1953; UBC 868L, entrance Kyuquot Sound, west coast of Vancouver Island, 3 July 1958) to Northern Washington (UBC 170L, Waadah Island, 15 July 1954).

Cladophora laetevirens (Dillwyn) Kützing, 1843, p. 263.[*]
Pl. 43, fig. E; pl. 47, fig. A.

Thallus erect, fairly rigid, yellowish green, usually profusely branched; 10–15 (–20) cm high. Main filaments 75–150 (–175) μ in diameter below with cells four to six times as long as broad; above somewhat narrower, 50–75 μ in diameter, usually two or three times as long as broad; terminating in short branchlets (two or three segments) with obtuse or subacute apices; branching irregular, sometimes with more or less dichotomous divisions in the main axes, often opposite; fastigiate at the tips of the axes.

There is a single, finely reticulate chloroplast with numerous pyrenoids. The walls are relatively thin.

Reproduction and life-history details presumably as described for the genus (*see* p. 85).

References:

Dillwyn, 1805, p. 66, pl. 48 (as *Conferva laetevirens*).
Kützing, 1843, p. 267; 1845, p. 214; 1849, p. 400; 1854, p. 3, pl. 15, fig. 1.
Harvey, 1849*a*, p. 202; 1858, p. 82; 1862, p. 177; 1871, pl. CXC.
Hauck, 1885, p. 458.
DeToni, 1889, p. 327.
Collins, 1902, p. 125, pl. 36, fig. 15; 1909*a*, p. 345; 1913, p. 104.
Setchell and Gardner, 1903, p. 224; 1920*a*, p. 216.

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[*] According to some authors (Hamel, 1926; Hoek, 1961) this species is conspecific with *Cladophora utriculosa* Kützing; however, the plant referred to *C. laetevirens* is not sufficiently well known, as it occurs on this Coast, to give an opinion in regard to this problem.

Børgesen, 1925, p. 65, fig. 26 (as *C. utriculosa*).
Hamel, 1926, p. 43, fig. 8A (as *C. utriculosa*).
Levring, 1937, p. 33.
Taylor, 1937, p. 90; 1957, p. 87.
Scagel, 1957, p. 54.
Söderström, 1963, p. 113–125, figs. 103–117.
Hoek, 1963, p. 128–140, figs. 409–429, 433, 440; 1964*a*, p. 90, 91.

Habitat. In the lower intertidal and upper subtidal zones.

Type Locality. Probably Swansea, England (K, *Conferva laetevirens*).

Pacific Coast Distribution. Southern British Columbia and Northern Washington.

Cladophora microcladioides Collins, 1909*b*, p. 17.*
Pl. 47, fig. B; pl. 48, fig. A; pl. 49, fig. A.

Thallus dull to glaucous green in colour, erect, loosely tufted, 5–10 (–20) cm high. Filaments in main axes are up to 100 (–200) μ in diameter near the base and 3–4 times as long as broad; above 60–80 μ in diameter and two to four (to six) times as long as broad; ultimate branchlets (30–) 40–50 μ in diameter and tapering slightly to slightly rounded apices. Branching of thallus below may be occasionally dichotomous or trichotomous; above filaments are more or less irregularly alternate, and the ultimate branches are usually recurved and have shorter branchlets secund along the adaxial side; branchlets generally simple and progressively shorter toward the apex of the axis.

The cell wall is thick and lamellose, especially in older portions of the plant.

There is a single, parietal, reticulate chloroplast with numerous pyrenoids up to 5 μ in diameter; the cell is multinucleate.

Reproduction and life-history details are apparently unknown in this species; presumably they are as described for the genus (*see* p. 85).

References:

Collins, Holden and Setchell, 1909, XXXII (No. 1583) (as *C. microcladioides* f. *stricta*).
Collins, 1909*b*, p. 17, pl. 78, figs. 2, 3; 1909*a*, p. 344; 1913, p. 104.
Setchell and Gardner, 1920*a*, p. 212, pl. 13, fig. 2.
Smith, 1944, p. 59, pl. 7, fig. 3.
Sanborn and Doty, 1947, p. 25.
Doty, 1947, p. 23.
Scagel, 1957, p. 55.

Habitat. On rocks in the lower intertidal and upper subtidal zones.

Type Locality. San Pedro, California.

Pacific Coast Distribution. Southern British Columbia (Port Renfrew, 15 May 1961 (UBC 445L)) to Mexico.

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*Although varietal status has been recognized in this species by some authors, there seems little justification for distinguishing such. In any case, as the specimens observed in this area are representative of the type, they should be regarded as *Cladophora microcladioides* Collins var. *microcladioides*.

Cladophora stimpsonii Harvey, 1859, p. 333.
Pl. 46, fig. E; pl. 48, figs. B, C.

Thallus erect, delicate, loosely tufted, 8–10 (–30) cm high, light green in colour; main filaments near the base are 100–150 (–160) μ in diameter; filaments above are narrower, in branchlets (20–) 25–40 (–50) μ in diameter, with cells five to eight times as long as broad and terminating in acute or subacute apices; branchlets long. The thallus in the main axes is dichotomously or trichotomously branched below, with the distal orders of branching forking, progressively smaller and becoming lateral and secund in the final orders.

There is a single, parietal, finely reticulate chloroplast with numerous pyrenoids; the cell walls are thick and lamellose, and the filaments are usually constricted at the septa.

Fertile segments are slightly larger than adjacent vegetative cells, and reproductive motile cells are liberated through a pore at the upper end of the cell. Reproduction and life-history details are incompletely known, but are presumably as described for the genus (*see* p. 85).

References:
Harvey, 1859, p. 333.
Collins, Holden and Setchell, 1900, XV (No. 729).
Collins, 1909*a*, p. 338; 1913, p. 104.
Setchell and Gardner, 1920*a*, p. 219.
Rigg and Miller, 1949, p. 332.
Tokida, 1954, p. 43, pl. II, figs. 1–4.
Scagel, 1957, p. 55.
Dawson, 1961, p. 378.

Habitat. On shells and stones in the intertidal zone.

Type Locality. Hakodate, Hokkaido, Japan (TCD, L, LD, *Cladophora stimpsonii*).

Pacific Coast Distribution. Southern British Columbia to Southern California.

Cladophora trichotoma (C. Agardh) Kützing, 1849, p. 414.*
Pl. 47, fig. C; pl. 48, fig. D; pl. 49, figs. B, C.

Thallus forming light to bright green hemispherical tufts or extensive spongy mats of somewhat stiff or wiry, branched filaments, 2–3 (–5) cm high, often considerably higher when growing in deep tide pools. The basal system is composed of procumbent filaments which are dichotomously or trichotomously branched; branching above comprises a few short branches, alternate or rarely opposite, fastigiate at the tips. Below the filaments are about 120–200 (–275) μ in diameter, and the cells are two to four (to six) times as long as broad; above the cells are 100–120 μ in diameter and four to ten times as long as broad; terminal cells usually taper slightly to a somewhat rounded apex. The thallus is attached to the substratum by irregular, simple or branched, septate or non-septate rhizoidal filaments, sometimes

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*Although varieties have been distinguished in *Cladophora trichotoma* by some authors, only one entity (*Cladophora trichotoma* (C. Agardh) Kützing var. *trichotoma*) is recognized in this treatment.

expanding at the tips to form disc-like masses of rhizoidal branches. The cell walls are thick and lamellose.

There is a single, parietal, finely to coarsely reticulate chloroplast with numerous pyrenoids; the cells are multinucleate.

Reproduction and life-history details are apparently unknown in the local plant; presumably they are as described for the genus (*see* p. 85).

References:

Agardh, 1824, p. 121 (as *Conferva trichotoma*).
Kützing, 1849, p. 414; 1854, p. 14, pl. 64, fig. 1.
Hauck, 1885, p. 448.
DeToni, 1889, p. 344.
Collins, Holden and Setchell, 1901, XVII (No. 820).
Setchell and Gardner, 1903, p. 226 (as *C. columbiana*), p. 226 (as *C. composita*); 1920*a*, p. 210, pl. 16, fig. 2.
Collins, 1909*a*, p. 226 (as *C. composita*), p. 349; 1913, p. 104.
Howe, 1911, p. 492.
Børgesen, 1925, p. 50, figs. 15, 16.
Hamel, 1926, p. 71, fig. 19, B.
Smith, 1944, p. 58, pl. 7, fig. 2.
Doty, 1947, p. 23.
Sanborn and Doty, 1947, p. 25.
Rigg and Miller, 1949, p. 332.
Scagel, 1957, p. 55.

Habitat. On rocks or in pools in the upper intertidal zone.

Type Locality. Atlantic coast of France.

Pacific Coast Distribution. Southern British Columbia (UBC 448L, Port Renfrew, 15 May 1961) to Mexico.

SPONGOMORPHA Kützing, 1843, p. 273.

Thallus made up of profusely branched, uniseriate filaments; in mature plants the major axes, particularly near the base, are bound or twisted together in spongy, rope-like strands by short, simple or compound, recurved or hook-like lateral branchlets, or by descending rhizoidal branches. The plant is attached by rhizoidal branches from the basal cells. The plants often grow in dense tufts or aggregations.

The cells are usually multinucleate, rarely uninucleate (*see* below). They contain a single, parietal, reticulate chloroplast; numerous pyrenoids are present. The terminal cells are usually larger and longer than other cells, usually blunt or rounded but sometimes acute at the end. Cell division is chiefly intercalary, but division of apical cells may also occur.

Vegetative reproduction occurs by fragmentation. Anteriorly biflagellate zoospores (probably mitospores) have been reported from undifferentiated, usually intercalary sporangia; these zoospores are produced in large numbers in the sporangium, and liberation is through a lateral pore in the cell wall.*

As far as is known, sexual reproduction is isogamous with anteriorly biflagellate gametes; the gametangia are intercalary and usually seriate; plants are unisexual.

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*There is some reason to believe that these so-called "zoospores" may be gametes (possibly with parthenogenesis occurring).

As far as is known, there is an alternation of heteromorphic generations in which the branched, haploid, gamete-producing generation alternates with a *Codiolum*-like, zoospore-producing phase (*see also* discussion on p. 77 and 106) or a *Chlorochytrium*-like, zoospore-producing phase (*see also* discussion on p. 103). Presumably these zoospores are meiospores, and the zygote is the only diploid cell of the life cycle. However, the occurrence of terminally biflagellate zoospores requires substantiation, and their development needs to be established.

Morphology and Reproduction:

Kützing, 1843, p. 273.
Wille, 1899, p. 281; 1900, p. 238; 1909, p. 117, 118.
Kjellman, 1893, p. 1–114, pls. 1–8.
Yendo, 1916, p. 245–247.
Printz, 1927, p. 275, 276, fig. 216 (as *Acrosiphonia*).
Smith, 1944, p. 64, 65, pl. 6, fig. 1.
Jónsson, 1957, p. 1251–1254, figs. 1–15; 1958, p. 325–328, figs. 1–14; 1959*a*, p. 1565–1567; 1959*b*, p. 1565–1567, fig. 1; 1960, p. 2390–2392, figs. 1–4; 1962, p. 25–230, figs. 1–48, pls. 1–16; 1963, p. 5187–5189; 1964*a*, p. 2145–2148, fig. 1; 1964*b*, p. 6207–6299 (as *Acrosiphonia*).
Fan, 1959, p. 1–12, figs. 1–14.
Archer and Burrows, 1960, p. 31–33.
Kornmann, 1961*c*, p. 195–205, figs. 1–6; 1962*c*, p. 219–242, figs. 1–11; 1963*b*, p. 60–68, fig. 1.
Hanic, 1965, p. 1–152, figs. 1–40.

According to some authors, including Wille (1899, p. 281; 1900, p. 238), the multinucleate species of this complex should be referred to the genus *Acrosiphonia*, and only uninucleate species should be considered as representative of the genus *Spongomorpha*. However, the Pacific Coast species have not been studied critically to determine the nuclear condition of the cells. There is some evidence indicating that multinucleate cells may occur in some of the Pacific Coast species (*see* p. 98, 99) presently referred to *Spongomorpha*. This criterion seems of questionable generic validity to me, but should it be adhered to, then it may become necessary eventually to refer some of the Pacific Coast species to *Acrosiphonia*. It should be pointed out, however, that the original diagnosis proposed by Agardh (1846, p. 12) to distinguish *Acrosiphonia* from *Spongomorpha* had nothing to do with the nuclear condition but referred to differences in length of segments in different regions of the filament. This latter criterion, at least, is certainly quite unsatisfactory to use to distinguish genera in this complex. Kornmann (1962*c*) considers *Acrosiphonia* to have an alternation of isomorphic generations and *Spongomorpha* to have an alternation of heteromorphic generations.

Key to Species of Spongomorpha

1. Curved or hooked, spine-like branchlets usually lacking; abundant simple or branched rhizoidal filaments present 2
1. Curved or hooked, spine-like branchlets present 3
    2. Plant dense, tufted but somewhat lax and not conspicuously matted and rope-like below; branching dichotomous or trichotomous or lateral; branch apices sometimes rounded, sometimes acute .... *S. saxatilis*, p. 99
    2. Plants dense, conspicuously matted, often rope-like below, usually fastigiate above; filaments fairly rigid; branch apices usually rounded, rarely acute .... *S. arcta*, p. 96
3. Curved or hooked, spine-like branchlets usually simple; filaments densely matted, except in extreme distal portions .... *S. spinescens*, p. 100
3. Curved or hooked, spine-like branchlets usually compound, plants rope-like, but not densely matted in distal portions 4
    4. Branchlets generally markedly curved and hooked, usually compound; except at apex, cells are usually shorter than broad or only slightly longer; thallus rope-like with a repeatedly branched macroscopic habit .... *S. coalita*, p. 97

4. Branchlets markedly curved and hook-like, often compound; cells throughout generally longer than broad; thallus more or less rope-like throughout but often only slightly, if at all, branched in macroscopic habit .... *S. mertensii*, p. 98

There has been little unanimity of opinion concerning the number of species and varieties of *Spongomorpha* present on the Pacific Coast in this area. Setchell and Gardner (1920*a*) have considered six species (with a number of varieties) for this area. Collins (1909*a*), on the other hand, has reduced a number of these to synonymy and considers four species, with several varieties for the same complex. There are at least three clear-cut entities, but a delimitation of species beyond this at the present time is somewhat problematical, and the designation of varieties, based chiefly on differences in cell size, seems scarcely tenable in such a variable and widespread complex. For the present, however, five species are recognized until the genus has been more carefully studied. *Spongomorpha duriuscula* (Ruprecht) Collins might also be expected in this area; it has been recorded from Alaska and Oregon (Okamura, 1933; Doty, 1947; Dawson, 1961). However, there are no records of its occurrence between these points, and the plant is not known in this area. This species is devoid of hooked branchlets and has proportionately much larger cells than recorded in any local species lacking hooked branchlets. From Doty's (1947, p. 24) description and comment I am inclined to think that his plant of this species from Oregon should be referred to *Cladophora trichotoma* (*see* p. 93).

Spongomorpha arcta (Dillwyn) Kützing, 1849, p. 417.
Pl. 37, figs. A–D; pl. 38, fig. A.

Thallus at first a bright green, later becoming darker; in dense hemispherical to globose tufts up to 10 (–15) cm high; filaments erect and fairly rigid. Filaments much branched, with branches mostly erect and free distally, becoming conspicuously matted together only near the base; branching irregularly alternate, occasionally opposite, often tending to become secund. Filaments of the main axes above are 60–100 (–150) μ in diameter, four to six times as long as broad and terminate in apical cells which have a rounded end and are sometimes obtuse or clavate; below the filaments are slightly narrower and usually shorter (1.5 to 3 times as long as broad). The apical regions of the lateral branches are occasionally somewhat acute. Rhizoidal filaments, which frequently branch and terminate in holdfasts, are abundant proximally and firmly mat together the axes near the base of the thallus; they are 30–50 (–60) μ in diameter and two to six times as long as broad. Curved or hooked branchlets are generally not present, although in the rhizoidal region of the plant there may be an occasional simple, short, curved branchlet, which soon usually becomes rhizoidal in nature.

There is a single, parietal, reticulate (varying from finely to coarsely perforate) chloroplast with numerous pyrenoids.

Intercalary fertile cells (presumably gametangia) have been observed, but otherwise reproduction and life-history details are apparently unknown in this species; presumably they are as described for the genus (*see* p. 91).

References:

Dillwyn, 1809, p. 67, pl. E (as *Conferva arcta*).
Kützing, 1843, p. 263 (as *Cladophora arcta*); 1845, p. 207 (as *C. arcta*); 1849, p. 417; 1854, p. 16, pl. 74, fig. 2.
Harvey, 1849*a*, p. 204 (as *Cladophora arcta*); 1849*b*, pl. 135 (as *C. arcta*); 1858, p. 75 (as *C. arcta*); 1862, p. 176 (as *C. arcta*); 1871, pl. CXXXV (as *C. arcta*).
Kjellman, 1883*a*, p. 304; 1893, p. 55 (as *Cladophora arcta*).

Hauck, 1885, p. 445 (as *Cladophora arcta*).
DeToni, 1889, p. 154 (as *Cladophora arcta*)
Hariot, 1889*b*, p. 154 (as *Cladophora arcta*).
Collins, Holden and Setchell, 1896, V (No. 224); 1901, XVII (No. 815) (as *Cladophora arcta*).
Collins, 1902, p. 115, pl. 36, fig. 1 (as *Cladophora arcta*); 1909*a*, p. 359; 1913, p. 104.
Setchell and Gardner, 1903, p. 224 (as *Cladophora arcta*); 1920*a*, p. 223.
Yendo, 1916, p. 245.
Hamel, 1926, p. 73, fig. 20 (as *Cladophora arcta*).
Newton, 1931, p. 88 (as *Cladophora arcta*).
Taylor, 1937, p. 93, pl. 6, figs. 5, 6; 1957, p. 90, pl. 6, figs. 5, 6.
Smith, 1946, p. 201–208, figs. 1–5.
Sanborn and Doty, 1947, p. 25.
Chapman, 1956, p. 444, fig. 95A.
Scagel, 1957, p. 56.
Levring, 1960, p. 12.
Kornmann, 1962*c*, p. 220–224, 232–235, figs. 1–4.
Parke and Dixon, 1964, p. 532 (as *Acrosiphonia arcta*).

Habitat. On rocks and epiphytic on other algae in the middle and lower intertidal zones.

Type Locality. Bantry Bay, Ireland (K, *Conferva arcta* Ruprecht).

Pacific Coast Distribution. Bering Sea to Oregon and in Chile. (UBC 572L, Haro Strait, west side of San Juan Island, Washington, 18 July 1959.)

Spongomorpha coalita (Ruprecht) Collins, 1909*a*, p. 361.
Pl. 37, figs. E, F; pl. 38, figs. B–E; pl. 39, figs. A, B.

Thallus at first bright green and loosely tufted; soon forming dense, rope-like, branching, dull or yellowish green tufts, 25–30 cm high; branches composed of branched uniseriate filaments. Filaments dichotomously branched in lower portion, becoming irregularly alternate or unilateral in upper portion; filaments 100–200 (–250) μ in diameter in the distal region, main axes terminating in blunt elongate apical cells, lesser orders often terminating in acute tips with smaller apical cells. Short, more or less determinate (but usually compound) branchlets are produced and become progressively more curved or hook-like toward the lower part of the thallus; these branchlets are particularly curved and branched in the tufted, rope-like portions of the thallus and are responsible for the matted habit by holding together adjacent axes. Some of these branchlets (or short branches on them) may become rhizoidal in nature near the base of the thallus and extend downward to produce an attachment structure.

Except for the terminal cell or a few cells below it, which may be at least two or three times the diameter in length, most of the cells in the main axes are 0.3–1.0 times as long as broad. The cells of the curved branchlets are generally progressively narrower and longer toward the apex of the thallus, often being quite irregular in shape in rhizoidal elements. The walls are usually thick and lamellose.

There is a single, parietal, reticulate chloroplast which contains numerous pyrenoids; the perforations are often finer and less distinct in mature cells.

Sexual reproduction is isogamous, and the plants are unisexual; the gametes are terminally biflagellate, 6–7 μ in length, pyriform, with a laminate chloroplast and an eyespot; the gametangia are undifferentiated intercalary cells. Most of the details relating to life history are reported from studies of this species on the Pacific Coast and are as described for the genus.

References:

Ruprecht, 1851, p. 404 (as *Conferva coalita* and *C. scopaeformis*).
Harvey, 1858, p. 75 (as *Cladophora cartilaginea* and *C. scopaeformis*).
Collins, Holden and Setchell, 1901, XVII (No. 819); XVIII (No. 902) (as *Cladophora scopaeformis*).
Setchell and Gardner, 1903, p. 226 (as *Cladophora hystrix*), p. 227 (as *C. scopaeformis* and *C. coalita*); 1920*a*, p. 230, pl. 16, fig. 4, pl. 32.
Collins, 1909*a*, p. 361; 1913, p. 104 (as *S. hystrix*).
Fritsch, 1935, p. 237, fig. 70, B, F.
Smith, 1944, p. 65, pl. 6, fig. 1: 1946, p. 201–208, figs. 1–5.
Sanborn and Doty, 1947, p. 25.
Doty, 1947, p. 24.
Rigg and Miller, 1949, p. 332.
Scagel, 1957, p. 57; 1961; Fasc. II, No. 40.
Fan, 1959, p. 4, figs. 1–12.

Habitat. On rocks and epiphytic on other algae in the middle and lower intertidal zones.

Type Locality. Northern California (*Conferva coalita* Ruprecht).

Pacific Coast Distribution. Kukak Bay, Alaska, to Carmel, California.

Spongomorpha mertensii (Ruprecht) Setchell and Gardner, 1920*b*, p. 280. Pl. 39, figs. C–G; pl. 40, figs. A–D.

Thallus bright green, up to 8 (–11) cm high; habit with a few long, usually unbranched and fairly lax, rope-like, erect, intertwined branches; branches composed of erect, branched, fairly rigid filamentous axes. Branching of filaments at first irregularly alternate, often opposite later and giving the general appearance of a dichotomously or trichotomously branched filamentous system. Filaments in the main axes above are 95–125 (–160) μ in diameter and usually 0.5–3 (–10) times as long as broad. Below, the filaments are smaller (80–95 μ in diameter) and shorter (0.5 to 2.5 times as long as broad). The wall is thick and lamellose. The apical cells of the main axes in the distal portion of the plant have rounded ends, rarely gradually tapering and somewhat acute. There are numerous short, simple or compound, curved or hook-like branchlets, the apical cell(s) of which are usually blunt or rounded. Rhizoidal filaments are abundant proximally, with cells proportionately longer than in the erect filaments, and form a more densely matted basal region.

There is a single, parietal, reticulate chloroplast with numerous pyrenoids. The cells may be multinucleate.

Intercalary fertile cells (presumably gametangia) have been observed, but otherwise life-history and reproductive details are apparently unknown in this species; presumably they are as described for the genus (*see* p. 91).

References:

Ruprecht, 1851, p. 403 (as *Conferva mertensii* and *C. viminea*)
DeToni, 1889, p. 317 (as *Cladophora mertensii* and *C. viminea*).
Collins, 1909*a*, p. 360 (as *S. saxatilis*); 1912, p. 97 (as *S. arcta* var. *limitanea*).
Collins, Holden and Setchell, 1911, XXXV (No. 1736) (as *S. arcta* var. *limitanea*).
Yendo, 1916, p. 246 (as *Acrosiphonia mertensii*).
Setchell and Gardner, 1920*a*, p. 227; 1920*b*, p. 280.
Nagai, 1940, p. 33, pl. II, fig. 3.
Sanborn and Doty, 1947, p. 25.
Doty, 1947, p. 24, pl. 6, figs. 10–12.
Tokida, 1954, p. 45.
Scagel, 1957, p. 57.

Collins (1909*a*) considers *Spongomorpha mertensii* (Ruprecht) Setchell and Gardner as a variety or growth form synonymous with *S. saxatilis* (Ruprecht) Collins. On the other hand, varieties have been described by some authors. *Spongomorpha mertensii* var. *tenuis* Tokida has been recorded by Tokida (1954, p. 47) from Saghalien; this plant differs apparently only in having rather larger filaments (180–200 (–300) μ in diameter). However, Tokida's concept of *Spongomorpha mertensii* (diameter of filaments less than 90 μ) is more restricted than that followed in this treatment. Nothing approaching these larger dimensions has been recorded for this Coast, and hence only the typical form (*Spongomorpha mertensii* (Ruprecht) Setchell and Gardner var. *mertensii*) is described here.

Habitat. In the middle and lower intertidal zones.

Type Locality. Sitka, Alaska (*Conferva mertensii* Ruprecht).

Pacific Coast Distribution. Unalaska Island, Alaska, to San Francisco, California (UBC 345L, Port Renfrew, British Columbia, 15 May 1961).

Spongomorpha saxatilis (Ruprecht) Collins, 1909*a*, p. 360.
Pl. 40, figs. E–G; pl. 41, figs. A–D.

Thallus at first bright green, later becoming darker, forming dense tufts of erect branches (but not matted into rope-like axes), up to 10 (–15) cm high. The filamentous branches are free from one another, except toward the base, where they are held together and to the substratum by narrow, branched rhizoidal filaments. The main axes terminate in blunt, apical cells, but most of the branches, except when young, terminate in tapered and somewhat acute apical cells. There are no curved or hook-like branchlets, although there may be simple, short, straight branchlets. Rhizoidal filaments are quite abundant toward the base. The filaments in the main axes are (75–) 80–120 (–160) μ in diameter above and three to six times as long as broad; below they are only slightly narrower and one to three times as long as broad; the rhizoidal filaments are branched, 20–30 μ in diameter, and the cells are proportionately longer than the cells in ordinary vegetative axes. Branching is more or less alternate but may be opposite, and the filaments may appear dichotomously or trichotomously branched.

There is a single, parietal, reticulate chloroplast, varying from cell to cell in degree of perforation, with numerous pyrenoids. The cells may be multinucleate.

Intercalary fertile cells (presumably gametangia) have been observed but otherwise life-history and reproductive details are apparently unknown in this species; presumably they are as described for the genus (*see* p. 91).

References:

Ruprecht, 1851, p. 403 (as *Conferva chamissonis*); p. 403 (as *C. saxatilis*).
Harvey, 1858, p. 75 (as *Conferva chamissonis*).
DeToni, 1889, p. 311 (as *Cladophora saxatilis*); p. 333 (as *Cladophora chamissonis*).
Collins, Holden and Setchell, 1902, XIX (No. 920) (as *Cladophora chamissonis*); 1902, XIX (No. 921) (as *S. saxatilis* var. *saxatilis*).
Setchell and Gardner, 1903, p. 224 (as *Cladophora chamissonis*); p. 223 (as *Cladophora saxatilis*); 1920*a*, p. 226 (as *S. saxatilis* var. *saxatilis*), p. 227 (as *S. saxatilis* var. *chamissonis*).
Collins, 1909*a*, p. 360 (as *S. saxatilis* var. *chamissonis*); 1913, p. 104.
Yendo, 1916, p. 245.
Nagai, 1940, p. 34, pl. II, figs. 6, 7.
Sanborn and Doty, 1947, p. 25.
Doty, 1947, p. 24.
Scagel, 1957, p. 58 (as *S. saxatilis* var. *chamissonis* and *S. saxatilis* var. *saxatilis*).

Varieties have been designated in this species, based chiefly on the stature of the plant and the differences in cell size, by several authors (Setchell and Gardner, 1920*a*; Collins, 1909*a*). However, these varieties appear to be ecological variants in the one species (cell diameter varies considerably depending on the age and part of the plant in which the measurements are taken). Most of the specimens observed by me have filaments exceeding the size designation for *S. saxatilis* var. *chamissonis* (Ruprecht) Collins and are, therefore, typical of *S. saxatilis* (Ruprecht) Collins var. *saxatilis*. However, I see little justification for varietal status in the species as it occurs on this Coast.

Habitat. On rocks and epiphytic on other algae in the intertidal zone (particularly in the lower intertidal zone).

Type Locality. Cap Nichta, Sea of Ochotsk (*Conferva saxatilis* Ruprecht).

Pacific Coast Distribution. Unalaska Island, Alaska, to San Francisco, California.

Spongomorpha spinescens Kützing, 1849, p. 418.
Pl. 41, figs. E, F; pl. 42, figs. A–I.

Thallus 5–10 cm high, at first bright green, later becoming lighter or yellowish, composed of a very dense intertwined system of branched filaments. The intertwined filaments below form stout rope-like axes which appear as if covered with short, spiny branchlets; and above, are somewhat looser terminating in free filaments. The filaments are (60–) 80–110 (–160) μ in diameter, usually slightly greater in diameter above than below, 0.5–4 (–10) times as long as broad, usually longer above and shorter below. There are numerous short, usually simple, branchlets, varying from slightly curved to markedly curved or even circinate. Simple or branched rhizoidal filaments are abundant, from 20–30 μ in diameter, with proportionately longer cells than in the ordinary vegetative portions of the filamentous system, and terminate frequently in non-septate or septate holdfasts. The holdfasts may attach to the substratum or to adjacent filaments.

The main axes terminate in blunt, rounded apical cells; lateral branches and branchlets have acute or spiny apices. Branching of the thallus is sometimes alternate or occasionally opposite, but often secund.

There is a single, parietal, reticulate chloroplast with numerous pyrenoids.

Intercalary* fertile cells (presumably gametangia) have been observed in the local plant, but otherwise reproduction and life-history details are apparently unknown for the Pacific Coast plant; presumably they are as described for the genus (*see* p. 91). Jónsson (1958) has reported on the European plant referred to this species (*see* p. 107 for discussion) and demonstrated an alternate *Codiolum* phase in the life history of *Spongomorpha spinescens* which he believes to be *Codiolum petrocelidis*. The sexual plants are isogamous and bisexual and the ovoid gametes are biflagellate.

References:

Kützing, 1849, p. 418 (as *Cladophora spinescens*); 1854, p. 16, pl. 75, fig. 2.

Harvey, 1862, p. 176 (in part as *Cladophora arcta* and in part as *C. scopaeformis*).

Kjellman, 1883*a*, p. 304; 1893, p. 51 (as *Acrosiphonia spinescens*).

DeToni, 1889, p. 335 (as *Cladophora arcta*).

Collins, Holden and Setchell, 1900, XV (No. 721) (as *Cladophora arcta* var. *centralis*).

Collins, 1902, p. 117, pl. 36, fig. 3 (as *Cladophora spinescens*); 1909*a*, p. 360, pl. XIV, fig. 126 (also as *S. arcta* f. *pulvinata*), p. 359 (as *S. arcta* f. *conglutinata*); 1913, p. 104 (also as *S. arcta* f. *conglutinata*).

Setchell and Gardner, 1903, p. 227 (as *Cladophora spinescens* and in part as *C. scopaeformis*), p. 223 (in part as *C. saxatilis*), p. 225 (in part as *C. arcta* f. *pulvinata* and *C. arcta* f. *conglutinata*); 1920*a*, p. 229.

Kylin, 1907, p. 22, fig. 4 (as *Acrosiphonia spinescens*); 1949, p. 60, fig. 60 as *A. spinescens*).

Printz, 1927, p. 276, fig. 216, A–D.

Hamel, 1926, p. 75 (as *Cladophora spinescens*).

Taylor, 1937, p. 94; 1957, p. 90.

Doty, 1947, p. 25, pl. 5, figs. 1, 5, 6.

Sanborn and Doty, 1947, p. 25.

Scagel, 1957, p. 58.

Jónsson, 1957, p. 1251–1254, figs. 1–15; 1958, p. 325, figs. 1–14; 1959*b*, p. 1565–1567, fig. 1; 1964*a*, p. 2145–2148, fig. 1; 1964*b*, p. 6207–6299 (as *Acrosiphonia spinescens*).

Levring, 1960, p. 12.

Habitat. On rocks and epiphytic on other algae in the middle and lower intertidal zones.

Type Locality. Bay of Biscay, Coast of Morbihan, France (L, 937,281 . . . 107, *Cladophora spinescens* Kützing).

Pacific Coast Distribution. Unalaska Island, Alaska, to Oregon and in Chile (UBC 1050L, Garden Island, entrance to Kyuquot Sound, British Columbia).

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*According to Kylin (1949, p. 60) terminal as well as intercalary cells can become fertile (presumably gametangia, although Kylin interpreted them as zoosporangia).

Order *CHLOROCOCCALES* Marchand *orth. mut. et emend.*
Pascher, 1915, p. 2.
Chlorococcoidées Marchand, 1895, p. 12.

Plants are unicellular and solitary, or non-filamentous colonies; sometimes forming dense aggregations; generally freshwater. The cells are uninucleate or multinucleate. The chloroplast is cup-shaped or laminate, entire or perforate, with one to many pyrenoids. The plants are non-motile during the vegetative phase of the life history and lack the capacity for true vegetative cell division.

When present, sexual reproduction is usually isogamous, by terminally biflagellate gametes, but may be anisogamous or oogamous. Reproduction also occurs by means of biflagellate or quadriflagellate zoospores, aplanospores (autospores), or akinetes.

Many of the plants are thought to be haploid, with the zygote the only diploid phase, but there is a suggestion that some may be diploid with the gametes the only haploid phase, and still others may have an alternation of heteromorphic generations (*see Codiolum*, p. 104).

KEY TO THE FAMILIES OF CHLOROCOCCALES

1. Thallus unicellular, sometimes endophytic within other algae .... CHLOROCOCCACEAE, p. 102
1. Thallus an irregularly branched filament, usually perforating shells of molluscs or wood .... GOMONTIACEAE, p. 107

Family CHLOROCOCCACEAE Blackman and Tansley, 1902, p. 95.

Plants unicellular, solitary, or forming dense aggregations; frequently endophytic within the cells of other algae. The cells vary in shape from globose to fusiform; sometimes developing into large irregularly shaped cells. The cell wall varies in thickness and frequently has lamellose extensions. The chloroplast is usually parietal and net-like or cup-shaped with one to several pyrenoids. The cells are uninucleate or multinucleate.

Where known, sexual reproduction is isogamous by terminally biflagellate gametes. Reproduction is also reported by zoospores (usually quadriflagellate), aplanospores, or akinetes.

KEY TO THE GENERA OF CHLOROCOCCACEAE

1. Cell with a basal stipe or pedicel; elongate and ovoid to clavate in shape .... CODIOLUM, p. 104
1. Cell without a basal stipe; oval or spherical in shape .... CHLOROCHYTRIUM, p. 102

CHLOROCHYTRIUM Cohn, 1872, p. 102.

Plant a unicellular, uninucleate cell; endophytic. The vegetative cell is globose, ovoid, or irregularly rounded. The wall is frequently thick and stratified or may be irregular with localized lamellose thickenings. The chloroplast is cup-shaped to net-like, sometimes with radiating processes, with one to several pyrenoids.

Sexual reproduction is reported to be isogamous by terminally biflagellate gametes; parthenogenesis is also reported to occur. The vegetative thallus is believed to be diploid with meiosis occurring at gametogenesis. The zygote develops directly into a large vegetative cell. Reproduction by quadriflagellate zoospores is also reported.

Morphology and Reproduction:

Cohn, 1872, p. 1–106, pls. I, II.
Klebs, 1881, p. 249–257, 265–272, 281–290, 297–308, 313–319, 329–336, pl. 3.
Moore, 1900, p. 100–112, figs. 1–14 (as *Chlorocystis*).
Gardner, 1917, p. 379–384, pl. 32, fig. 6.
Setchell and Gardner, 1920*a*, p. 146, pl. 13, fig. 1; pl. 15, fig. 1.
Kurssanow and Schemakhanova, 1927, p. 131–146, figs. 1, 2, pls. IX and X.
Smith, 1938, p. 93, fig. 45; 1944, p. 66, pl. 8, figs. 1, 2; 1955, p. 92, fig. 45.
Jónsson, 1959, p. 1565–1567.
Parke and Dixon, 1964, p. 530.

According to Jónsson (1959, p. 1565), *Chlorochytrium inclusum* Kjellman is a unicellular and multinucleate diploid, zoospore-producing phase of the multicellular and multinucleate sexual, biflagellate, and isogamous gamete-producing species *Spongomorpha lanosa* (Roth) Kützing. This further complicates the whole problem (*see* p. 72 for discussion) relating to affinities and nomenclature of species (and phases) known under the genera *Codiolum*, *Urospora*, *Spongomorpha*, and *Chlorochytrium*. According to Parke and Dixon (1964), *Chlorochytrium* should be referred to the family Endosphaeraceae in the order Chlorococcales.

Key to Species of Chlorochytrium

1. Cell elliptical with a papillate thickening of the wall in the region nearest to surface of host; endophytic in various foliose floridean algae; embedded amongst the cells of the host .... *C. inclusum*, p. 103
1. Cell spherical; endophytic in membrane of species of *Porphyra* .... *C. porphyrae*, p. 104

Chlorochytrium inclusum Kjellman, 1883, p. 320.*
Pl. 9, fig. A.

Cell ovoid, usually apiculate in the mature condition with the protuberance extending toward the surface of the host; 75–100 μ in diameter; endophytic within the superficial cells of the thallus of various foliose floridean algae.

Chloroplast generally net-like with numerous pyrenoids.

Reproduction isogamous by terminally biflagellate gametes which escape from a pore in the cell wall.

References:

Kjellman, 1883, p. 320, pl. 31, figs. 8–17.
DeToni, 1889, p. 637.
Rosenvinge, 1893, p. 963; 1899, p. 119.
Collins, Holden and Setchell, 1898, XI (No. 514).
Freeman, 1899, p. 195, pl. XIX.
Setchell and Gardner, 1903, p. 206; 1920*a*, p. 147, pl. 13, fig. 1.
Collins, 1909*a*, p. 147; 1913, p. 101.
Hamel, 1928, p. 12, fig. 3E.
Newton, 1931, p. 50, fig. 33.
Levring, 1937, p. 15.
Taylor, 1937, p. 43; 1957, p. 42.
Nagai, 1940, p. 4.
Smith, 1944, p. 67, pl. 8, fig. 2.

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*[*See* p. 72 for discussion of relationship of *Chlorochytrium inclusum* Kjellman to a species of *Spongomorpha*.

Doty, 1947, p. 27.
Kylin, 1949, p. 9, fig. 4, A–D.
Tokida, 1954, p. 69, pl. VII, figs. 15, 16.
Scagel, 1957, p. 59.
Lund, 1959, p. 15.

Habitat. Endophytic in *Schizymenia, Constantinea, Weeksia, Iridaea,* and various other foliose red algae in the intertidal and subtidal zones.

Type Locality. Arctic Ocean, endophytic in species of *Dilsea.*

Pacific Coast Distribution. Sitka, Alaska, to Carmel, California.

Chlorochytrium porphyrae Setchell and Gardner, *in* Gardner, 1917, p. 379.
Pl. 9, figs. B–H.

Cell spherical to obspherical, 40–60 μ in diameter; endophytic within the membrane or mucilaginous matrix of the host on both surfaces of the thallus.

Chloroplast single, cup-shaped, becoming enlarged with radiating processes or reticulate in the mature condition; single pyrenoid.

Reproduction isogamous by terminally biflagellate gametes which escape from a pore in the cell wall.

References:

Gardner, 1917, p. 379, pl. 32, fig. 6.
Collins, 1918, p. 26.
Collins, Holden and Setchell, 1919, XLVI (No. 2280).
Setchell and Gardner, 1920*a*, p. 150, pl. 15, fig. 1.
Smith, 1944, p. 67, pl. 8, fig. 1.
Doty, 1947, p. 28.
Scagel, 1957, p. 59.

Habitat. Endophytic in *Porphyra perforata* and *P. lanceolata.*

Type Locality. Lands End, San Francisco, California (UC 205703).

Pacific Coast Distribution. Northern Washington to Monterey, California.

CODIOLUM Braun,* 1855, p. 19.

Plant unicellular, free-living or endophytic, ovoid to clavate. The lower region of the cell is usually elongated to form a colourless pedicel which is confluent with the wall material surrounding the pigmented portion of the cell. The chloroplast is reticulate, with one to several pyrenoids; mature vegetative cells are reported to have several nuclei.

Reproduction is by quadriflagellate zoospores (probably meiospores), and aplanospores have also been reported. The whole cell functions as the sporangium and a large number of spores are produced. Sexual reproduction is not fully known. It would appear, however, that the species of *Codiolum* probably all represent stages in the life history of algae known as species of *Urospora, Spongomorpha,* and perhaps even other genera.

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*According to Parke and Dixon (1964) *Codiolum* should be placed in the family Characiaceae in the order Chlorococcales.

Morphology and Reproduction:

Braun, 1855, p. 19–24, figs. 1–17.
Kuckuck, 1894, p. 259–261, fig. 27; 1896, p. 396–397, fig. 20.
Jorde, 1933, p. 1–19, figs. 1–5, pl. 1.
Hollenberg, 1957, p. 76; 1958, p. 249–251, figs. 1–6.
Jónsson, 1957, p. 1251–1254, figs. 1–15; 1958, p. 325–328, figs. 1–14.
Fan, 1959, p. 1–12, figs. 1–41.
Kornmann, 1960, p. 59–71, figs. 1–8; 1961*a*, p. 42–57, figs. 1–9; 1961*b*, p. 252–259, figs. 1–5; 1963*b*, p. 60–68, fig. 1; 1961*c*, p. 195–205, figs. 1–6.
Parke and Dixon, 1964, p. 530.
Hanic, 1965, p. 1–152, figs. 1–40.

Key to Species of Codiolum

1. Plant with a short stipe, endophytic .... *C. petrocelidis*, p. 106
1. Plant with a long stipe usually, free-living .... *C. gregarium*, p. 105

Codiolum gregarium A. Braun, 1855, p. 20.
Pl. 7, figs. F–M; pl. 8, figs. A–E.

Plant unicellular, multinucleate, free-living, generally stipitate (but sometimes short and almost sessile); (280–) 375–425 μ in length with diameter of pedicel near point of attachment to substratum about 25 μ; pigmented portion of cell (45–) 55–80 μ in diameter (generally smaller in diameter when sterile). Cells are reported to contain three to five nuclei in the vegetative condition. Shape of thallus is typically clavate, tapering rather gradually from the hyaline stipitate basal attachment region to the enlarged, elliptical distal portion.

A distinctive form of this plant (Pl. 7, figs. F–M), which is retained in the *C. gregarium* complex for the present, has a stipitate region which merges much more abruptly with the distal pigmented region of the cell; the pigmented region is elliptical to ovoid. The pedicel frequently has a wrinkled appearance.

Quadriflagellate zoospores, typically with a spine-like posterior projection, are produced. Zoospores are uninucleate, 8–10 μ in diameter, 20–25 μ in length (not including the flagella). The flagella are 20 μ in length and inserted at the blunt anterior end. A single conspicuous pyrenoid is present in the chloroplast of the zoospore.

After a brief free-swimming period the zoospores settle to the substratum and germinate to form a *Urospora*-stage (*see* p. 77).

Although several forms have been described for this species (*see also* p. 106), only one variety (*C. gregarium* A. Braun var. *gregarium*) is recognized in this treatment.

References:

Braun, 1855, p. 20, figs. 1–17.
Hauck, 1885, p. 471, fig. 207.
DeToni, 1889, p. 631.
Collins, Holden and Setchell, 1896, IV (No. 165).
Oltmanns, 1904, p. 175, fig. 107.
Collins, 1909*a*, p. 152, pl. V, fig. 37.
Setchell and Gardner, 1920*a*, p. 151, pl. 15, fig. 2.
Hamel, 1928, p. 15, fig. 3B.
Newton, 1931, p. 53, fig. 37.

Jorde, 1933, p. 1, figs. 1–5, pl. I.
Jao, 1937, p. 99, fig. 6 (as *C. pusillum* f. *subsessile*).
Taylor, 1937, p. 40; 1957, p. 40.
Papenfuss, 1950*a*, p. 81, fig. 2.
Scagel, 1957, p. 60; p. 58 (as *C. pusillum* f. *subsessile*).

Habitat. On rocks, shells, logs, and old iron in the intertidal zone.

Type Locality. Helgoland, Germany.

Pacific Coast Distribution. Southern British Columbia to Northern Washington.

Codiolum petrocelidis Kuckuck, 1894, p. 259.
Pl. 8, figs. F, G.

Plant unicellular, multinucleate, endophytic, with a narrow stipitate basal region; pedicel frequently long but sometimes almost lacking. Sometimes the pedicel is somewhat lateral in position. The cell is globose to ovoid in the apical region, often tapering abruptly below. The plant is 125–175 μ in length and 25–50 μ in diameter in the pigmented region. The plant is attached to and completely embedded amongst the filamentous system of species of *Petrocelis*. For the *Spongomorpha*-stage (*see* p. 94).

References:

Kuckuck, 1894, p. 259, fig. 27; 1896, p. 396, fig. 20.
Collins, 1909*a*, p. 152.
Collins, Holden and Setchell, 1919, XLVI (No. 2281).
Setchell and Gardner, 1920*a*, p. 152.
Hamel, 1928, p. 14, fig. 3A.
Newton, 1931, p. 53.
Fritsch, 1935, p. 153, fig. 41, K, O.
Taylor, 1937, p. 41; 1957, p. 41.
Smith, 1944, p. 68.
Kylin, 1949, p. 10, fig. 5.
Scagel, 1957, p. 60.
Hollenberg, 1957, p. 76; 1958, p. 249, figs. 1–6.
Fan, 1957, p. 75; 1959, p. 1, figs. 1, 6, 7, 22–35.
Jónsson, 1958, p. 325, figs. 1–14; 1959*b*, p. 1565–1567, fig. 1.

Habitat. Endophytic in *Petrocelis franciscana* Setchell and Gardner and *P. middendorffii* (Ruprecht) Kjellman.

Type Locality. Helgoland, Germany.

Pacific Coast Distribution. Northern Washington to Monterey, California.

The work of Jorde (1933) indicates that *C. gregarium* Braun is probably an alternate stage in the life history of *Urospora mirabilis* Areschoug (= *U. penicilliformis* (Roth) Areschoug); the observations of Hollenberg (1957 and 1958) suggested and Fan (1957 and 1959) demonstrated that *C. petrocelidis* Kuckuck is an alternate stage in the life history of *Spongomorpha coalita* (Ruprecht) Collins. In view of these findings, the "species" of *Codiolum* should be reduced to synonymy under the respective genera (and *Urospora* would have to be conserved). However, the degree of variation amongst the *Codiolum* stages as well as the presence of several species of *Spongomorpha* and *Urospora* recorded in this area, makes it impossible at this point in our knowledge to fully clarify the taxonomic position (and nomenclatural status) of these entities. Silva (1957*a*) has already pointed out that *Codiolum* has priority over *Urospora*. But Fan (1957 and 1959) and Hollenberg (1957 and 1958) have shown that *Spongomorpha* is also involved in this complex, and hence, even though *Codiolum* has priority over

Urospora, obviously all the plants referred to *Codiolum* cannot now be referred to the one genus. A *Codiolum* stage has also been reported in a marine species of *Ulothrix* (Kornmann, 1963*a*). The genus *Codiolum* is, therefore, retained here for the present as a separate entity for descriptive purposes. The relationships of *Gomontia* in this complex are discussed by Kornmann (1959, 1960, 1961*a*, 1961*b*, 1961*c*). However, there does not appear to be any justification for considering Jao's (1937) *C. pusillum* f. *subsessile* Jao as a valid entity. The range of forms encountered in *C. gregarium* Braun certainly encompasses Jao's *C. pusillum* f. *subsessile;* and furthermore, Jao's material is more like *C. gregarium* (L, No. A.937,351 . . . 187) than *C. pusillum* (Lyngbye) Kjellman. However, a free-living form of *Codiolum* has been found in this area that does not appear distinctive from *C. gregarium;* it has been found fertile there in early spring, and the shape of the fertile cell is different from that found in typical *C. gregarium*. The development of quadriflagellate zoospores from this form has been observed, and it has also been found that a *Urospora* stage represents an alternate stage in its life history. However, gametes have not been observed from this plant. It should be noted, nevertheless, that the quadriflagellate zoospores (*see* pl. 7, fig. J) are morphologically similar to those produced in *Urospora* and quite unlike the zoospores described and illustrated by Fan (1959) in *Codiolum petrocelidis* (= *Spongomorpha coalita*) and by Jónsson (1958) in *Codiolum petrocelidis* (= *Acrosiphonia spinescens*). Fan (1959) assumed that the zoospores were the same as those described by Kuckuck (1896, p. 397, fig. 20), but he did not observe free-swimming spores, nor did he determine the morphology and number of flagella. Although this form might well be regarded as *C. gregarium* var. *intermedium* (Foslie) Collins or perhaps even as a new species of *Codiolum*, because of the present status of the genus *Codiolum* and its relation to the other genera mentioned above, this form is retained for the present within the typical *C. gregarium* complex.

Family GOMONTIACEAE Bornet and Flahault *ex* DeToni,* 1889, p. 389.

Thallus, a branched filament; cells irregular in shape, uninucleate in vegetative condition, often multinucleate when mature; chloroplast parietal, laminate or reticulate with one to several pyrenoids.

Reproduction by quadriflagellate (or biflagellate) zoospores, aplanospores, or akinetes produced within large irregular sporangia. Sporangia often becoming detached before maturation of zoospores.

Sexual reproduction not well known; but biflagellate isogametes are reported.

Only one genus, *Gomontia*, in this family is represented in the local flora.

GOMONTIA Bornet and Flahault, 1888, p. 163.

Thallus composed of branched filaments of irregular cells; usually endozoic within empty shells. Cells uninucleate or multinucleate; when young with a parietal lobed or reticulate chloroplast with one to several pyrenoids. Cells near the surface of the substratum enlarge, become thick-walled and function as sporangia; quadriflagellate zoospores (probably meiospores) are produced at maturity; aplanospores have also been reported.

Sexual reproduction apparently occurs; biflagellate cells, which are probably anisogamous gametes, have been reported.

Kylin (1935*b*) considers the so-called sporangium of *Gomontia* to be a *Codiolum*-like alga, but Smith (1944) believes the typical vegetative condition to be filamentous as described here. Although quadriflagellate zoospores are produced by *Gomontia*, their

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*Kornmann (1960) considers *Gomontia* (*see* p. 108 for discussion) to be a member of the Chaetophoraceae. However, until the whole complex involving a number of relationships with *Codiolum* and *Chlorochytrium* is better known this family is retained in the Chlorococcales.

shape is not the same as that found in the motile cells produced in *Codiolum* (*gregarium?*) and *Urospora* (*see* p. 76). Kornmann (1959) has presented further evidence in support of Kylin's opinion from culture studies. Kornmann obtained plants which produced quadriflagellate zoospores and plants which produced biflagellate gametes. From Kornmann's work, especially from the shape of the zoospores, it is obvious that his material bears no relationship to the *Codiolum-Urospora* situation. Kornmann (1960) has referred the filamentous phase to the genus *Eugomontia.* Kornmann (1962*a*, 1962*b*) also draws attention to the similarity of the zygote in *Monostroma* and *Gomontia.* However, the status of *Gomontia,* as far as the local material is concerned, can still not be satisfactorily clarified. The justification for returning *Gomontia polyrhiza* to *Codiolum polyrhizum* and for referring the filamentous phase to *Eugomontia* (as Kornmann suggests) is at present of questionable validity and will remain so until the whole complex involving *Urospora, Spongomorpha, Monostroma, Codiolum,* and *Chlorochytrium* is more completely studied. According to Parke and Dixon (1964) *Gomontia* should be referred to the family Endosphaeraceae in the order Chlorococcales.

Morphology and Reproduction:

Bornet and Flahault, 1888, p. 163; 1889, p. clii–clx, pls. 6–8.
Setchell and Gardner, 1920*b*, p. 298–300, pl. 23, figs. 1, 2, pl. 24, figs. 1–3; 1920*a*, p. 300–304, pl. 18, figs. 1, 2, pl. 19, figs. 1–3.
Oltmanns, 1923, p. 473, 474, fig. 765.
Kylin, 1935*b*, p. 186–191, figs. 1, 2.
Kornmann, 1959, p. 229–238, figs. 1–9; 1960, p. 59–71, figs. 1–8; 1962*a*, p. 37–39; 1962*b*, p. 195–202, figs. 1–5; 1963*b*, p. 60–68, fig. 1.
Chihara, 1962, p. 44, 45.
Parke and Dixon, 1964, p. 530.

Gomontia polyrhiza (Lagerheim) Bornet and Flahault, 1888, p. 164.
Pl. 10, figs. A–E.

Thallus giving a green colour to the calcareous substratum. Filaments irregularly branched; cells 4–10 μ in diameter and 20–50 μ in length; cells uninucleate in vegetative condition. Sporangia irregularly shaped 50–150 μ in diameter and 150–250 μ long; quadriflagellate zoospores ovoid, 7–9 μ long and 4–5 μ wide, uninucleate, with a laminate to cup-shaped chloroplast; containing a single pyrenoid and an eyespot. The flagella are inserted at the apical end and are 12–15 μ in length.

References:

Lagerheim, 1885, p. 22, pl. 28, figs. 1–16; 1886, p. 65 (as *Codiolum polyrhizum*).
Bornet and Flahault, 1888, p. 163; 1889, p. clviii, pls. 6–8.
DeToni, 1889, p. 389.
Wille, 1890, p. 120, fig. 80.
Collins, Holden and Setchell, 1897, VII (No. 315).
Setchell and Gardner, 1903, p. 229; 1920*a*, p. 302, pl. 19, fig. 1; also p. 302 (as *G. bornetii*), p. 304, pl. 19, figs. 2, 3 (as *G. habrorhiza*) and pl. 18, figs. 1, 2 (as *G. caudata*); 1920*b*, p. 298, pl. 24, fig. 1 (also as *G. bornetii*), p. 299, pl. 24, figs. 2, 3 (as *G. habrorhiza*), p. 300, pl. 23, figs. 1, 2 (as *G. caudata*).
Collins, 1909*a*, p. 370, pl. XV, fig. 135; 1913, p. 105.
Hamel, 1928, p. 34, fig. 11, A–E.
Newton, 1931, p. 96, fig. 63.
Fritsch, 1935, p. 272, fig. 83, C, I, J.
Levring, 1935, p. 10; 1937, p. 16.
Kylin, 1935*b*, p. 1; 1949, p. 11, figs. 6, 7.
Taylor, 1937, p. 58, pl. 1, figs. 13, 14, pl. 7, fig. 4; 1957, p. 59, pl. 1, figs. 13, 14, pl. 7, fig. 4.

Smith, 1944, p. 41, pl. 1, figs. 8–11, pl. 2, figs. 1–7.
Doty, 1947, p. 7.
Rigg and Miller, 1949, p. 332.
Chapman, 1956, p. 438, fig. 92a.
Scagel, 1957, p. 61.
Lund, 1959, p. 17.

Habitat. In empty shells in the intertidal zone.

Type Locality. Kristineberg, Sweden.

Pacific Coast Distribution. Southern British Columbia to Monterey, California.

Order *CODIALES* Feldmann, 1954, p. 97.

Siphonales Wille, *in* Warming (1884) *orth. mut.*
Blackman and Tansley, 1902, p. 114.
Caulerpales Feldmann, 1946, p. 753.
Siphoneae Wille, *in* Warming, 1884, p. 33.

Plant body of freely branched or aggregated filaments or a globose vesicle, usually with a prostrate rhizoidal attachment region; usually macroscopic. The thallus consists of a single multinucleate cell, usually tubular and generally branched. If tubular, the filamentous branches may arise freely, or they may be compacted to form a macroscopic thallus of definite form. The thallus may be dichotomously branched or the branches may be irregular in distribution or definitely arranged along an axis. The thallus may or may not be calcified (lime encrusted). Although transverse septa are generally lacking in the vegetative phase, they may be produced at the base of the gametangia and sporangia and in some instances at points in the vegetative thallus. Such septa are formed by centripetal growth of ring-like thickenings and are frequently compound in structure (a pair of transverse walls). In certain genera, although septa per se are absent in the vegetative portion of the thallus, an elaborate system of internal strands or trabeculae traverse the lumen of the cell and form a network.

The chloroplasts are small and numerous, disciform or fusiform, and may or may not contain pyrenoids. In addition to the usual green pigments in the chloroplasts, the members of this group possess two distinctive xanthophylls (siphonein and siphonoxanthein) not found in other members of the Chlorophyceae. Another distinctive biochemical characteristic found commonly in the group is the presence of callose instead of cellulose in the cell wall.

Sexual reproduction may be isogamous, anisogamous, or oogamous, and the gametangia may or may not be morphologically differentiated from the vegetative condition. The gametangia may or may not be cut off by septa. Reproduction may also occur by multiflagellate (stephanokont) meiospores (zoospores or aplanospores), usually produced within differentiated sporangia. Akinetes are rare but are produced by certain genera.

Except for the anomalous type of life history reported for *Derbesia* (*see* p. 111), the thallus is a diploid, non-septate, multinucleate plant. It produces biflagellate gametes either in modified portions of the thallus or in specialized gametangia, with meiosis occurring at gametogenesis.

KEY TO THE FAMILIES OF CODIALES

1. Plant composed of sympodially branched filaments interwoven to form a compact thallus (with a palisade-like layer of utricles making up the cortex), usually spongy in texture and with distinctive macroscopic form .... CODIACEAE, p. 117
1. Plant not a compact thallus 2
   2. Plant profusely branched with numerous short determinate branchlets arising from erect, percurrent, more or less indeterminate axes .... BRYOPSIDACEAE, p. 121
   2. Plant an unbranched globose vesicle or an irregularly, sometimes unilaterally or pseudodichotomously and sparsely branched filament .... DERBESIACEAE, p. 110

Family DERBESIACEAE (Thuret) Hauck, 1884, p. 421.
Derbesieae Thuret, *in* LeJolis, 1863, p. 14.
Derbesiales Feldmann, 1954, p. 97.

In what is believed (*see* discussion below) to be the sporophytic phase (the *Derbesia*-stage), the thallus is a simple or sparingly branched, tubular, non-septate, multinucleate cell in which the branches are not interwoven to form a macroscopic, spongy plant body of definite form. The branching is irregular, unilateral, or subdichotomous without percurrent axes. In what is believed to be the gametophytic phase (the *Halicystis*-stage), the thallus is a globose to pyriform, unbranched, non-septate, multinucleate cell with a colourless rhizome-like portion penetrating the substratum. The chloroplasts are numerous, usually discoid, with or without a pyrenoid.

Reproduction in the *Derbesia*-stage is by ovoid multiflagellate (stephanokont) zoospores (probably meiospores), which are produced within differentiated sporangia; the sporangia are terminal or lateral in position and are cut off at the base by a septum. The flagella lie in a transverse whorl or ring at the anterior end of the zoospores, somewhat similar to those in Oedogoniales. Spherical aplanospores are also reported. On germination the zoospores are believed to give rise normally to the *Halicystis*-stage. It has been suggested that these sporangia may also produce mitospores instead of meiospores, as an accessory method of reproduction, and that these might be capable of giving rise directly to the *Derbesia*-stage.

The relationship between two entities of green algae in the Siphonales, *Derbesia* and *Halicystis*, which have been regarded until fairly recently as the type genera of two distinct families, Halicystidaceae and Derbesiaceae, is a classical example of the value of culture studies in elucidating the life histories of marine algae. In characterizing the genus *Derbesia*, Tilden (1935) had postulated that it was "altogether probable that the 'plant' in *Derbesia* [was] a sporophyte and that the gametophytic plant [might] be discovered if [a] careful search [were] made." However, apparently she anticipated an alternation of isomorphic generations.

Hollenberg (1935 and 1936) was one of the first to undertake a detailed study of *Halicystis* in culture. He showed conclusively that the vesicular thallus of the plant in California, referred to *Halicystis ovalis* (Lyngbye) Kjellman, was gametophytic in nature and produced anisogamous biflagellate gametes. In working with *Derbesia marina* in Europe, however, Kornmann (1938) found that the stephanokont zoospores from this plant gave rise to non-septate filaments. These filaments eventually produced vesicles resembling plants of *Halicystis ovalis*. The vesicles became fertile, just as Hollenberg had described in *Halicystis* previously, and produced anisogamous motile cells which also resembled the gametes he had described. Kornmann (1938) did not observe biflagellate cells fusing. However, he believed they were gametes since he obtained non-septate, multinucleate filaments in his cultures from germinating "zygotes," which he believed to be early stages in the development of "*Derbesia*" plants. However, the "*Derbesia*" plants did not become fertile in culture. Later, starting with anisogamous gametes obtained from *Halicystis parvula* Schmitz in Europe, Feldmann (1950) and later Ziegler and Kingsbury (1964) obtained zygotes which developed into filaments resembling *Derbesia*. These plants, which subsequently produced sporangia and zoospores in culture, were identical to *Derbesia tenuissima* (Mor. and DeNot.) Crouan *frat.* Although Feldmann (1950) believed the stephanokont zoospores were meiospores and would give rise to the *Halicystis* stage, just as Kornmann had already shown in *Derbesia marina*, he also considered it probable that at times the zoosporangia might produce mitospores which could give rise directly to *Derbesia* plants. The fact that *Derbesia tenuissima* is known in Britain, whereas *Halicystis parvula* is not (Parke, 1953), lends further support to Feldmann's hypothesis. The fact that *Derbesia* is frequently encountered regionally in areas where *Halicystis* is unknown is also strongly suggestive of this possibility. However, more careful exploration may yet turn up *Halicystis* in all such areas, as has been reported by Iyengar and Ramanathan (1954) and Chapman (1964). The author (Scagel, 1959), working with the Pacific Coast plant *Halicystic ovalis*, obtained results in culture somewhat similar to those of Feldmann, although the "*Derbesia*" filaments remained sterile.

Although further work is needed to clarify the cytological aspects of these studies, the morphological evidence, in spite of Kornmann's failure to obtain sporangia on the "*Derbesia*" filaments and Feldmann's and Scagel's (*see* p. 114 and 116) failure to get back to *Halicystis* thalli in their cultures, indicates rather conclusively that these two "genera" are merely stages in the life history of the same alga. Although these two phases are considered as separate entities to some extent for taxonomic purposes in the treatment below, the species should probably now be regarded as *Derbesia marina* (Lyngbye) Kjellman with *Halicystis ovalis* (Lyngbye) Areschoug being a synonym (Silva, 1957). However, the discovery of a *Derbesia* stage (*D. neglecta*) in the life history of *Bryopsis* (*B. halymeniae*) further complicates the picture (Hustede, 1960, 1964). For the present, *Derbesia* is retained in the family Derbesiaceae, although Feldmann (1954) has suggested that the stephanokont nature of the motile cell is sufficiently distinctive to warrant the erection of the order Derbesiales to include *Derbesia* and *Halicystis*.

The status of the other species of *Derbesia* which have been recorded from this area is considered below.

KEY TO THE "GENERA" OF DERBESIACEAE

1. Plant an unbranched globose vesicle ...... DERBESIA (HALICYSTIS-stage), p. 114
1. Plant an unbranched or sparingly branched filament .... DERBESIA (DERBESIA-stage), p. 111

DERBESIA Solier, 1846, p. 453.

Thallus tubular, non-septate, and multinucleate, with a prostrate interwoven system of irregularly branched and lobed haptera. An erect system of loosely branched bright green tufts of filaments arises from the prostrate system. The erect portion may be dichotomously branched, but unilateral and irregular branching throughout are also common. Occasional transverse septa develop, particularly at the base of the branches; the septa may be simple or compound. The compound septa formed at the base of the branches may form a short cell which contains chloroplasts and nuclei.

Within the tubular thallus in the mature region, a thin layer of cytoplasm surrounds a large central vacuole. In the cytoplasm are many small nuclei and many small discoid or spindle-shaped chloroplasts without or with (one to three) pyrenoids. In the same species, depending on the depth at which the plant grows, the number of pyrenoids varies from three to none. In plants growing in deeper water they are frequently absent.

Multiflagellate or stephanokont zoospores (believed to be meiospores) are produced within sporangia which are borne laterally on erect filaments. The sporangium arises in a fashion similar to that of a new vegetative branch, but the fertile branches soon cease elongating and increase in diameter, and septa from the supporting axes eventually cut them off. The septum formed at this point is compound. It results from an annular ingrowth of the lateral wall of the constricted pedicel supporting the sporangium. Although the young sporangium at first contains a very large number of small nuclei (over one hundred in the local species, *D. marina*), shortly after the septum forms a few nuclei enlarge considerably, and the remaining smaller nuclei eventually degenerate. The multinucleate protoplast then undergoes division resulting in 10 to 50 daughter protoplasts each containing a single large nucleus and numerous small discoid chloroplasts. Eventually these protoplasts metamorphose into ovoid multiflagellate zoospores, which escape when the wall of the sporangium undergoes an irregular rupture. The flagella are arranged in a subterminal collar or a transverse whorl at one pole of the motile cell.

The zoospores swim about for a brief period and, after coming to rest, withdraw the flagella, secrete a wall, and germinate. On germination a nonseptate, multinucleate filament results which eventually produces vesicles (the *Halicystis*-stage). Hence, the alga has an alternation of heteromorphic generations with meiosis occurring presumably in the zoosporangium of the *Derbesia*-stage. Aplanospores, which may be meiospores (or mitospores), have also been reported.

For sexual reproduction and structure of the gametophyte, *see* under *Halicystis* (p. 114), and also refer to the discussion above.

Morphology and Reproduction:

Solier, 1846, p. 452–454; 1847, p. 158, pl. 9, figs. 1–17.
Davis, 1908, p. 1, figs. 1–27.
Mirande, 1913*a*, p. 212–219, figs. 18–22; 1913*b*, p. 475.
Fritsch, 1935, p. 386, fig. 122, E, G, H.
Kornmann, 1938, p. 464, figs. 1–4.
Smith, 1938, p. 115, fig. 60; 1944, p. 71, pl. 8, fig. 4; 1955, p. 110, fig. 58.
Feldmann, 1950, p. 323; 1954, p. 96.
Magne, 1956, p. 488–490, figs. 1, 2.
Kornmann, 1963*b*, p. 60–68, fig. 1.
Hustede, 1964, p. 134–142, figs. 1–4.
Ziegler and Kingsbury, 1964, p. 103–116, figs. 1. 2.

The following is an attempt to evaluate the three species (*Derbesia marina*, *D. pacifica*, and *D. vaucheriaeformis*) recorded for this area.

After studying cultures of living material from this region and herbarium specimens from several other areas, I have concluded that only one species should be recognized for the area dealt with in this manual. The criteria used for species distinction in this genus have never been entirely satisfactory. They have been chiefly related to the diameter of the tubular thallus of the vegetative filaments, the size and shape of the chloroplasts, the size (diameter and length) and shape of the sporangia, and the size (diameter and length) of the pedicel supporting the sporangium. Judging from culture studies with plants from this area, these characteristics are somewhat variable. Børgesen (1925) had already emphasized this morphological variability, particularly with reference to the size of the sporangium and diameter of the tubular thallus, in his treatment of species of *Derbesia* from the Canary Islands. In instances where both *Halicystis*- and *Derbesia*-stages are known, the relationship seems fairly obvious. However, where only species of *Derbesia* are recorded, there is needed a further search for the possible occurrence of mitospores and perhaps even additional affinities in the life history of other entities of green algae.

The occurrence of *Derbesia pacifica* Jao in this area (Scagel, 1957, p. 63) is based entirely on a record of Jao (1937) from the San Juan Islands, Washington. This is a poorly founded species. From Jao's description and illustration of the species, and after a study of some of his material, I see no justification for considering this as a species distinct from *D. marina*. The diameter of the tubular filaments, the dimensions of the sporangia and the pedicels, and the number of zoospores in the sporangium all fall within the range of variation encountered in *D. marina*.

Similarly, the occurrence of *Derbesia vaucheriaeformis* (Harvey) J. Agardh is reported in part from observations made by Jao (1937) in Washington, but it is also based on collections made by Saunders in California (1899, p. 3) and by the same author (1901, p. 415) in Alaska. Setchell and Gardner (1920*a*) had already suggested that Saunders' plant was more closely related to *D. marina*, but Jao (1937) felt it should be referred, as Saunders (1901) had, to *D. vaucheriaeformis*. Smith has reported a similar narrow form with branches 20–25 μ in diameter in California, which he also refers to *D. marina*. The broader concept of variability for the species *D. marina* as accepted by Setchell and Gardner (1920*a*) and Smith (1944) and confirmed by my observations justifies referring all these plants to the one species, *D. marina*, the type of the genus. These comments refer specifically to the Pacific Coast plants referred to *D. vaucheriaeformis* and not necessarily to *D. vaucheriaeformis* (Harvey) J. Agardh per se. The type of this species, described by Harvey (1858, p. 30) as *Chlorodesmis vaucheriaeformis*, was collected in Key West, Florida. I have examined Harvey's material (in Trinity College, Dublin) and also duplicate material he apparently sent to Agardh (in Herbarium Agardh, Lund, No. 15404), and find the tubular thallus in both these specimens measures 40–90 μ in diameter.

Only one species is recognized in the area.

Derbesia marina (Lyngbye) Solier, 1847, p. 158.
Pl. 1, figs. A–I.

Plants about 1–4 cm high, occurring as erect tufts of loosely branched, bright green filaments with a basal, irregularly branched, rhizoidal attachment system. The erect portion appears more or less dichotomously branched, tending to become obscure and unilaterally or irregularly branched in the mature portions of the thallus. The thallus is a tubular multinucleate cell measuring 18–40 (–70) μ in diameter with the branch apices gradually tapering to subacute tips.[*] The discoid chloroplasts, which are 2 μ in their greatest dimension, are numerous; with one to three or without pyrenoids. At some points in the tubular thallus they are densely packed together, but at other points they are widely scattered. Starch grains, particularly in older filaments, may be very abundant.

Simple and compound (a pair of transverse walls) septa occur occasionally in the vegetative regions, and the compound septa are usually, but not always present near the base of a vegetative branch. Most of the branches are initiated subapically, but they may also arise proximal to the compound septa.

Large, ovoid to subspherical sporangia, measuring 70–85 μ in diameter and 100–150 μ in length replace ultimate branchlets. The sporangia are attached by a narrow stalk or pedicel measuring 15 μ in diameter and 20–30 μ in length. The sporangia are always cut off from the vegetative portions of the thallus by compound septa. Several sporangia may occur along one axis, sometimes at intervals of less than 250 μ. The septa make up the major portion of the pedicels.

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[*] A fragment of Lyngbye's type material of *D. marina* was apparently studied by Kjellman, and this, together with Kjellman's original drawings, was observed in Uppsala; the thallus in the type material measures 35–40 μ in diameter.

The number of zoospores produced in the mature sporangium seems to vary but is usually about 32 to 48. The zoospores, as seen within the sporangium, are about 20–30 μ in diameter. In the motile, free-swimming condition they are slightly ovoid and typically stephanokont. Mature zoosporangia have been found in the area in early spring (Port Renfrew, British Columbia, 5 April, 1961) and in late summer (Waadah Island, Washington, 15 August, 1958, RFS 581L). The *Derbesia*-stage has been grown in continuous culture from plants of *Halicystis* collected in Haro Strait, on the west side of San Juan Island, Washington, in August 1959; these plants have remained sterile in culture.

For sexual reproduction and structure of the gametophyte, *see* under *Halicystis ovalis* (p. 116).

References:

Lyngbye, 1819, p. 79, pl. 22, fig. A (as *Vaucheria marina*).
Harvey, 1871, pl. CCCL (as *Vaucheria marina*).
Kjellman, 1883*a*, p. 316; 1883*b*, p. 387; 1897, p. 3, figs. 1–14.
Agardh, 1887, p. 34.
DeToni, 1889, p. 426.
Saunders, 1899, p. 3, pl. 350, fig. 4 (as *D. vaucheriaeformis*); 1901, p. 415.
Collins, Holden and Setchell, 1899, XII (No. 574) (as *D. tenuissima*).
Setchell and Gardner, 1903, p. 230 (also as *D. vaucheriaeformis*); 1920*a*, p. 165, pl. 15, fig. 3.
Oltmanns, 1904, p. 308, fig. 191.
Collins, 1909*a*, p. 407, pl. 17, fig. 152.
Fritsch, 1935, p. 386, fig. 122, E, G, H.
Levring, 1937, p. 35.
Jao, 1937, p. 106, figs. 11–13 (as *D. pacifica*); p. 107, fig. 14 (as *D. vaucheriaeformis*).
Smith, 1938, p. 115, fig. 60; 1944, p. 71, pl. 8, fig. 4; 1955, p. 110, fig. 58.
Doty, 1947, p. 28.
Kylin, 1949, p. 68.
Papenfuss, 1950*a*, p. 82, fig. 1, a–c.
Chapman, 1956, p. 473, fig. 132a.
Magne, 1956, p. 488, figs. 1, 2.
Scagel, 1957, p. 63 (also as *D. pacifica*); p. 64 (as *D. vaucheriaeformis*).
Dawson, 1962, p. 278.

Habitat. Growing on rocks, sponges, and epiphytic on articulated and encrusting coralline algae in the lowermost intertidal zone and in the subtidal zone to a depth of several fathoms.

Type Locality. Quivig, Faeroe Islands (*Vaucheria marina* Lyngbye, 1819).

Pacific Coast Distribution. Adak Island, Alaska (UBC 7727) to Southern California and Mexico.

HALICYSTIS J. E. Areschoug, 1850, p. 446.

Thallus, an erect, globose to pyriform multinucleate, non-septate plant with a prostrate attachment system of colourless rhizoidal filaments which penetrate the substratum. One or more globose vesicles may be produced from the same non-septate system. The cell wall, which is stratified, is tough and transparent. It is generally quite thick in the vesicular portion and much thinner in the rhizoidal region of the thallus. A thin layer of cytoplasm, in which lie numerous discoid chloroplasts and small nuclei, lines the inner surface of the cell wall, and a large central vacuole constitutes the greater part of the vesicular portion of the thallus and may also extend a short distance into the rhizoidal region. Pyrenoids are absent, but starch grains are usually abundant. Older vesicles have a transverse abscission region extending across the thickened basal portion of the wall. The vesicular region can be severed below this layer and not only retains its turgor but can become fertile repeatedly over a period of at least several months.

In the vegetative condition the vesicle appears a rather uniform green colour, although prior to becoming fertile the uneven arrangement of the chloroplasts may give a streaked appearance to the thallus.

Extensive regions of the thallus are given over to sexual reproduction in gametangial regions in the globose part of the plant. These become well demarcated as dark, irregular patches, and each fertile area has one to several clearer areas which are destined to become discharge pores. Anisogamous sexual reproduction occurs, and the plant is unisexual. The gametes are not formed in differentiated gametangia; they are produced within the globose thallus, although they are demarcated by a layer of cytoplasm into gametangial regions. The male gametophyte produces a fertile region that is a lighter, opaque green colour; the female produces a dark green, almost black area. The gametes are terminally biflagellate. They are liberated forcibly through the discharge pores, following which the thallus is decidedly flaccid for a short period before it regains its usual turgid condition. The same vesicle may become fertile repeatedly (in the Pacific Coast plant, *H. ovalis*, about every 14 days). Parthenogenetic development of female gametes is indicated from culture studies.

Vegetative reproduction can occur from the rhizoidal system. Old rhizomes are apparently perennial and can regenerate new vesicles for a number of successive years.

For vegetative structure and production of zoospores and aplanospores in the sporophytic phase, *see* under *Derbesia* (p. 111) and refer to the discussion on p. 111.

Morphology and Reproduction:

Kuckuck, 1907, p. 139–185, figs. 1–25, pl. 3, figs. 1–13.
Smith, 1930, p. 224–227, figs. 1, 2; 1938, p. 107–111, figs. 56, 57; 1944, p. 70, pl. 9, fig. 1; 1955, p. 106–111, figs. 55–57.
Hollenberg, 1935, p. 782–812, figs. 1–5, pls. 1–4; 1936, p. 1–3, fig. 1.
Fritsch, 1935, p. 373, 374, fig. 116.
Kornmann, 1938, p. 464–470, figs. 1–4.
Feldmann, 1950, p. 323; 1954, p. 96.
Iyengar and Ramanathan, 1954, p. 446–452, figs. 1–19, pl. 16.
Magne, 1956, p. 488–490, figs. 1, 2.
Abelard and Feldmann, 1958, p. 1, 2.
Ziegler and Kingsbury, 1964, p. 103–116, figs. 1, 2.

Only one "species" is recognized from the area.

Halicystis ovalis (Lyngbye) Areschoug, 1850, p. 447.
Pl. 2, figs. A–F.

Plants usually up to 1 cm in diameter, occasionally up to 15 mm; dirty green in colour. The vesicular part is spherical, usually tapering slightly toward the attaching rhizoidal portion of the thallus. The vesicular portion is most abundant during the summer months but may be present throughout the year. The plants become fertile at each series of low tides, and fertile plants are present at any of these periods throughout the year. The same 14-day (approximately) cycle of reproduction is maintained in laboratory cultures, although it can be upset temporarily by cold shock or a prolonged period of darkness for several days.

The male plants produce brownish green fertile regions; the female plants produce conspicuous greenish black fertile regions. The male gametes are slender, averaging 1.5 μ in diameter at the widest point and 7.5 μ in length; the flagella are about 15 μ long. The female gametes are stouter, averaging 7.5 μ in diameter at the widest point and 10.5 μ in length; the flagella are about 15 μ long. The anterior, tapered end of both gametes has a short, blunt projection, and the flagella are inserted on opposite sides of this projection.

The gametes fuse to give rise to a zygote about 8 μ in diameter which germinates and, within a few days, develops into a non-septate, multinucleate filament—the sporophytic *Derbesia*-stage. This juvenile stage is at first 5–6 μ in diameter.[*]

For structure of the sporophyte and its reproduction, *see* under *Derbesia marina* (p. 113).

References:

Lyngbye, 1819, p. 72, pl. 18, fig. B (as *Gastridium ovale*).
Agardh, 1822, p. 431 (as *Valonia ovalis*).
Kützing, 1843, p. 305 (as *Botrydium ovale*).
Areschoug, 1850, p. 447.
Saunders, 1899, p. 2, pl. 350, fig. 2, a and b (as *Valonia ovalis*).
Setchell and Gardner, 1903, p. 232 (as *Valonia ovalis*); 1920*a*, p. 155, pl. 14, fig. 3.
Kuckuck, 1907, p. 139–157, figs. 1–4, pl. 3, figs. 1–13.
Collins, 1909*a*, p. 372, pl. 14, fig. 130; 1913, p. 105.
Smith, 1930, p. 224, figs. 1, 2; 1938, p. 108, figs. 56, 57; 1944, p. 70, pl. 9, fig. 1; 1951, p. 52, fig. 14, A–D; 1955, p. 106, figs. 55–57.
Hamel, 1928, p. 106, fig. 34, 1, 2.
Newton, 1931, p. 99.
Hollenberg, 1935, p. 782, figs. 1–5, pls. 1–4; 1936, p. 1, fig. 1.
Fritsch, 1935, p. 373, 374, fig. 116.
Doty, 1947, p. 28.
Sanborn and Doty, 1947, p. 26.
Kylin, 1949, p. 63, fig. 62.
Papenfuss, 1950*a*, p. 81, fig. 3.
Magne, 1956, p. 488, figs. 1, 2.
Scagel, 1957, p. 61; 1959, p. 203.

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[*] The author had in continuous culture from July 25, 1957, to August 1961, "*Derbesia*" filaments that were initiated from zygotes of *Halicystis*. These grew vigorously but remained sterile.

Habitat. Epiphytic on encrusting coralline algae in rocky regions in the lowermost intertidal zone on the open coast; subtidally to a depth of several fathoms in both exposed and sheltered portions of the Coast.

Type Locality. Faeroe Islands (*Gastridium ovale* Lyngbye, 1819).

Pacific Coast Distribution. Admiralty Island (Quast, AB62-88) and Silver Bay, Alaska, to Baja California, Mexico.

Family CODIACEAE Kützing, *corr.* Hauck, 1884, p. 421.
Codieae Kützing, 1843, p. 308.

Thallus prostrate or erect, with or without lime encrustation, composed of a much-branched tubular, primarily non-septate and multinucleate cell with free or intertwined filaments, usually organized into a spongy plant body of definite macroscopic form; globose, cushion-like or cylindrical, or erect and foliose. Branching of filaments is usually sympodial. The branched filaments are frequently organized into a palisade-like cortical layer of swollen utricles at the surface of the thallus and a central medulla of narrow branches. A rhizoidal system of branches forms an attachment disc in the erect species. Numerous small nuclei and discoid chloroplasts are present in the cell, and pyrenoids are lacking.

Anisogamous sexual reproduction occurs by biflagellate gametes produced in specially formed gametangia which are laterally situated on the utricles and cut off with a basal septum. The thallus is diploid with meiosis occurring at gametogenesis; plants are bisexual or unisexual. Sporangia and biflagellate zoospores have been reported in some genera, but these reports have not been substantiated.

Only one genus, *Codium,* is present in the flora of the region.

CODIUM Stackhouse, 1797, p. 16.

Thallus erect or prostrate, composed of intertwined non-septate, multinucleate filaments compacted to form a macroscopic spongy plant body of definite form, and definite or indefinite shape and size. The thallus may be flat and encrusting, globose or cylindrical and erect. Thallus not encrusted with lime. In the mature condition the branched filaments of the thallus are organized into a medulla of longitudinal, intertwined, colourless filaments, and a cortex composed of an epidermal layer of inflated photosynthetic vesicles (utricles). The utricles are usually cylindrical and may have colourless hairs. New utricles arise usually as branches of older utricles. They are sealed off at the point of connection by annular thickenings which eventually form a septum.

The chloroplasts are small and numerous and restricted to the utricles.

Anisogamous sexual reproduction occurs by biflagellate gametes. The gametes are markedly different in size, and, on this basis, the gametangia can be clearly distinguished as to sex, even prior to liberation. The gametes are produced in differentiated gametangia which are borne laterally on the utricles. The utricles are sealed off at the base of the gametangia by annular thickenings. The plants are generally unisexual and meiosis occurs at gametogenesis. Parthenogenetic development of female gametes occurs in some species.

Morphology and Reproduction:

Saunders, 1899, p. 1, 2, pl. 350, figs. 1, a–d, 3, a–c.
Mirande, 1913*a*, p. 219–232, figs. 24–35.
Oltmanns, 1922, p. 396–401, figs. 257–259.
Schmidt, 1923, p. 1–67, figs. 1–44.
Smith, 1930, p. 228–231, fig. 3; 1938, p. 111–114, figs. 58, 59; 1944, p. 74, pl. 9, figs. 4, 5; 1955, p. 111–115, figs. 59, 60.
Setchell, 1940, p. 443–448, figs. 1–5.
Silva, 1951, p. 79–105, figs. 1–32, pls. 1–6; 1955, p. 565–577, figs. 1–5, pl. 1.
Silva, *in* Egerod, 1952, p. 381–395, figs. 11–18, pl. 34, fig. b, pl. 35, fig. b.
Silva and Womersley, 1956, p. 261–289, pls. 1–3, figs. 1–16.
Feldmann, 1956, p. 305–307.
Dangeard, 1958*c*, p. 65–88, pls. 1–4.
Delépine, 1959, p. 366–395, figs. 1–11.

Key to Species of Codium

1. Thallus unbranched, forming a flattened encrusting layer or a globose mass 2
1. Thallus erect, cylindrical and dichotomously branched .... *C. fragile*, p. 118
  2. Utricles less than 150 μ in diameter .... *C. setchellii*, p. 121
  2. Utricles more than 500 μ in diameter (clearly distinguishable at the surface of the thallus with the naked eye) .... *C. ritteri*, p. 120

Codium fragile (Suringar) Hariot, 1889, p. 32.
Pl. 2, figs. G–M; pl. 3, figs. A–C.

Thallus erect, up to 40 cm high, dichotomously branched, with several orders of cylindrical branches 3–10 mm in diameter; frequently several thalli arise from a common, broad, spongy, basal disc; dark green to greenish black in colour; at times coated with whitish hairs.

The medullary filaments are 26–112 μ in diameter. The utricles are unbranched, narrowly to broadly clavate, (150–) 240–350 (–650) μ in diameter and (600–) 675–1125 (–1500) μ in length; apex acuminate, usually terminating in a distinct spine about 120 μ long, sometimes sharp but variable and at other times blunt or even lacking, usually with two colourless hairs arising from the upper portion of each utricle.

The plants are unisexual. Gametangia have a short pedicel attaching them laterally toward the upper end of the utricle; they are ovate or clavate, (45–) 75–170 μ in diameter and (145–) 220–450 μ in length; from one to three gametangia, which mature consecutively, may develop on a single utricle. Mature gametangia are found from mid-May through September.

The entity designated here as *Codium fragile* (Suringar) Hariot is described in the broadest sense to include a rather variable series of plants. Whether distinct subspecies should be recognized cannot be strongly supported until further ecological and taxonomic studies have been undertaken. A number of varieties of *C. fragile* have recently been recognized in Britain and Australia (Silva, 1955; 1957*c*; 1959; Silva and Womersley, 1956), and there is probably equal justification for considering two in the North Pacific. The extremes in the series, based chiefly on the apical characteristics (presence or absence and degree of sharpness of spine) of the utricles, have previously been considered by some authors as distinct varieties in this area, although under names which are probably no longer valid for the entities under discussion. The very acute spine at the apex of the utricles was the basis for distinguishing *C. fragile* (Suringar) Hariot var. *californicum* (J. Agardh) Collins, 1912, p. 99 (= *C. mucronatum* J. Agardh var. *californicum* J. Agardh, 1887, p. 44, pl. 1, fig. 3). The blunter character (or even absence of spine) of this apical region was the basis for distinguishing *C. fragile* (Sur.) Hariot var. *novae-zelandiae* (J. Agardh) Collins, 1912, p. 99 (= *C. mucronatum* J. Ag. var. *novae-zelandiae* J. Agardh, 1887, p. 44). If subspecies or varieties are to be recognized for these two extremes, with intergrades between, the former entity (with sharp spine), which comes closest to the type, should be regarded on this coast as *C. fragile* (Suringar) Hariot var. *fragile*, and the latter (blunt spine or absent) should be referred to a new variety rather than *C. fragile* var. *novae-zelandiae*. The type of *C. fragile* from Japan (L, 963) has rather consistently and sharply pointed spines at the apex of the utricles. However, this characteristic is extremely variable, even within the same individual, and in the Pacific Coast specimens may vary from a sharp point to a blunt tip; or the apex of the utricle may be rounded and quite devoid of any trace of a spine or protuberance. Another feature should be noted also: the degree of invagination of the apical region of the utricle (or the thickness of the apical wall). In the type (L, 963), other specimens from Japan (UBC 7313), and in many of the specimens from Alaska (UBC 10501) and the west coast of Vancouver Island (UBC 3894), there is a deep invagination in the apex (and the apical region has a wall that is uniform in thickness) very like the type. In many specimens, however, it is customary to find the wall of the utricle markedly thickened at the apex, so that the utricle is almost completely devoid of any invagination.

References:

Turner, 1811, p. 1 (as *Fucus tomentosus*).
Postels and Ruprecht, 1840, p. 25 (as *C. tomentosum*).
Harvey, 1858, p. 29; 1862, p. 176 (as *C. tomentosum*).
Suringar, 1867, p. 258, pl. 8, figs. 1–4 (as *Acanthocodium fragile*).
Agardh, 1887, p. 44, pl. 1, fig. 3 (as *C. mucronatum* var. *californicum*).
Saunders, 1889, p. 1, pl. 350, fig. 1, a–d (as *C. mucronatum* var. *californicum*); 1901, p. 416 (as *C. mucronatum*).
DeToni, 1889, p. 495.
Hariot, 1889*a*, p. 32.
Collins, Holden and Setchell, 1896, V (No. 229) (as *C. mucronatum* var. *californicum*).
Setchell and Gardner, 1903, p. 232 (as *C. mucronatum* var. *californicum* and *C. mucronatum* var. *nova zelandiae*); 1920*a*, p. 171, pls. 28, 29.
Collins, 1909*a*, p. 389 (as *C. mucronatum*); 1913, p. 105 (as *C. fragile* f. *californicum* and *C. fragile* f. *nova zelandiae*).
Hurd, 1916*b*, p. 109, pls. 19–24 (as *C. mucronatum*).
Smith, 1930, p. 228, fig. 3; 1938, p. 111, figs. 58, 59; 1944, p. 75, pl. 9, fig. 5; 1955, p. 112, figs. 59, 60.
Levring, 1937, p. 34.
Sanborn and Doty, 1947, p. 26.
Doty, 1947, p. 30.
Kylin, 1949, p. 67.
Rigg and Miller, 1949, p. 332.
Silva, 1951, p. 96, fig. 22.
Feldmann, 1956, p. 305–307.
Scagel, 1957, p. 64; 1960*a*, Fasc. I, No. 22.
Dangeard, 1958*c*, p. 79, pl. 3.

Habitat. Growing attached to rocks in the middle and lower intertidal zones and the upper subtidal zone; common in larger tide pools.

Type Locality. Japan (*Acanthocodium fragile* Suringar, 1867).

Pacific Coast Distribution. Sitka, Alaska, to Mexico.

Codium ritteri Setchell and Gardner, 1903, p. 231.
Pl. 3, figs. D–J; pl. 4, figs. A, B.

Thallus, when young, globose, spongy, and prostrate; later, forming an expanded encrusting mass at least 10 cm in diameter and 3–4 cm in thickness. The medullary filaments measure 45–60 μ in diameter, and the utricles are 400–800 μ in diameter and 1800–2500 μ in length. The utricles are clavate; the rounded apex of the utricle has a small depression, and the end wall, which is thicker, is lamellate. The end wall has delicate internal pitting or sculpturing which can be seen in sectional and surface views. New utricles which arise from older ones by lateral branching are cut off at the base by a septum. Each utricle has at least one and sometimes several rhizoidal filaments arising from its base.

The gametangia are unknown.

Although this species is still poorly known, its occurrence in Alaska is now well established. In addition to records of its occurrence at Berg Bay (Setchell and Gardner, 1903) it is known from Kodiak Island (Saunders, 1901, as *C. adhaerens*), Atka Island (Okamura, 1933), Attu Island (UBC 10038), and Adak Island (UBC 7767 and 10011). The record of its occurrence on the west coast of Vancouver Island stems from Setchell's examination of Tilden's (1900, IV, No. 370) *C. adhaerens* from "Baird Point" and his referral of the plant to *C. ritteri* (Setchell and Gardner, 1920*a*, p. 170). Extensive collections have now been made in this area of Vancouver Island, and, although *C. setchellii* is widespread, confirmation of the presence of *C. ritteri* south of the type locality in Alaska is still lacking. Tilden's locality ("Baird Point") has been thoroughly examined. I have examined Tilden's No. 370 (MIN 5572 and US) from "Baird Point" as well as the type (Saunder's No. 350) identified as *C. adhaerens* (US) from Kodiak Island and find these both agree with the material collected from Attu and Adak islands in the Aleutians. The most striking feature of this species is the extremely large size of the utricles, in contrast to other Pacific Coast species. It comes closest perhaps to *C. mamillosum* Harvey. Setchell and Gardner (1903, p. 232) suggested that *C. mamillosum,* which is recorded in Japan, was probably referable to *C. ritteri*. However, Okamura (1915, p. 152) pointed out that the shape of the utricle in the Japanese plant was different from that of *C. ritteri*. I have compared the recent material collected on rocks in the lower intertidal region at Attu and Adak islands (UBC 7767; 10011; 10038) with specimens identified as *C. mamillosum* from Australia (UBC 2728), which is the type locality for *C. mamillosum*, and Japan (UBC 7321) and with the descriptions of the plants from these localities as well as from Hawaii (Okamura, 1915; Egerod, 1952; Silva and Womersley, 1956) and find that all three entities appear quite distinct in the size, shape, and certain structural characteristics of the inner surface of the wall in the apical region of the utricles. The utricles in *C. ritteri* are generally considerably shorter, but broader than those of the Japanese plant; and they are considerably shorter and narrower than in the Australian plant.

References:

Tilden, 1900, IV, No. 370 (as *C. adhaerens*).
Saunders, 1901, p. 180 (as *C. adhaerens*).
Setchell and Gardner, 1903, p. 231, pl. 17, figs. 8–11; 1920*a*, p. 169, pl. 16, fig. 5.
Collins, 1909*a*, p. 387; 1913, p. 105.
Okamura, 1915, p. 152; 1933, p. 86.
Silva, 1951, p. 84.
Scagel, 1957, p. 65.

Habitat. On rocks in the lower intertidal and upper subtidal zones.

Type Locality. Berg Bay (near entrance to Glacier Bay), Alaska.

Pacific Coast Distribution. Attu Island (UBC 10038) to Berg Bay, Alaska, with certainty and possibly to the west coast of Vancouver Island, British Columbia.

Codium setchellii Setchell and Gardner, 1903, p. 231.
Pl. 4, figs. C–H.

Thallus forming an extensive spongy encrusting layer, irregular in outline, and closely adherent to the substratum; dark green to almost black in colour. The thallus is 5–15 mm thick with an extensive medullary system of intertwined filaments 15–30 μ in diameter and a cortical system of frequently branched utricles. The utricles are cylindrical to clavate, frequently with a slight constriction just below the truncate or slightly rounded apex; they are 45–125 μ in diameter and 650–1200 μ long. The end wall is thickened and in older utricles is lamellate.

The plants are unisexual. The gametangia, which are cylindrical to fusiform in shape, are borne singly on a short pedicel attached about 300–350 μ from the apex of the utricle; they are 45–67 μ in diameter and 210–330 μ in length and do not protrude beyond the apex of the utricles. The gametes are liberated through an apical pore in the gametangium. Mature gametangia are found mid-May through September.

References:

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Saunders, 1899, p. 2, pl. 350, fig. 3, a–c (as *C. adhaerens*).
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Collins, 1909*a*, p. 387: 1913, p. 105 (as *C. adhaerens*); 1918, p. 88 (as *C. dimorphum*).
Hurd, 1916*a*, p. 211, pl. 37, figs. 1–13 (as *C. dimorphum*).
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Sanborn and Doty, 1947, p. 26.
Doty, 1947, p. 30.
Rigg and Miller, 1949, p. 332 (as *C. adhaerens*).
Silva, 1951, p. 83, fig. 2.
Scagel, 1957, p. 65; 1960*a*, Fasc. I, No. 21.

Habitat. On rocks in the lower intertidal and upper subtidal zones.

Type Locality. Pacific Grove, California.

Pacific Coast Distribution. Sitka, Alaska, to Mexico.

Family BRYOPSIDACEAE Bory *orth. mut.* DeToni, 1888, p. 449.
Bryopsideae Bory, 1829, p. 203.

The thallus is composed of a cluster of erect, tubular, non-septate, and multinucleate branches, arising freely from a prostrate rhizoidal basal system; sometimes forming cushion-like growths. The erect branches may be further branched irregularly into several orders of branching with the ultimate branches once or twice pinnately arranged either distichously or radially;

usually with percurrent axes. The branches are never compacted to form a plant body of distinctive form. The cell wall is composed of cellulose. The chloroplasts are numerous, disciform, each with one or more conspicuous pyrenoids.

Anisogamous sexual reproduction occurs by means of biflagellate gametes formed usually in ordinary pinnate branchlets which function as gametangia when they are cut off from the vegetative portion of the thallus by septa. As far as is known, the plants are unisexual and diploid, and meiosis occurs at gametogenesis.* The zygote germinates immediately and develops into a new diploid thallus. Zoospores or other types of reproductive structures have not been reported, although vegetative reproduction by the abscission of branchlets is common in some species.

Only one genus in the family, *Bryopsis,* is represented in the flora.

BRYOPSIS Lamouroux, 1809, p. 133.

Thallus a tubular, non-septate, and multinucleate plant composed of a cluster of erect branches with a percurrent axis and with filiform branchlets in the ultimate orders arranged distichously or radially.

The chloroplasts are discoid with one to several conspicuous pyrenoids. The ultimate filiform branchlets function as gametangia when basal septa form, separating off the vegetative portion of the thallus. The plants are unisexual. Anisogamous sexual reproduction occurs by means of terminally biflagellate gametes. The gametangia usually arise as ordinary branchlets which are generally cut off at the base by a double septum; occasionally gametes form within the axis. Meiosis occurs at gametogenesis.* Vegetative reproduction commonly occurs in some species by abscission of branchlets, which then develop into new plants.

Morphology and Reproduction:

Lamouroux, 1809, p. 133–135, pl. 3, fig. 1, a, b.
Pringsheim, 1871, p. 240–255, figs. 1–15.
Mirande, 1913*a*, p. 201–211, figs. 11–16.
Oltmanns, 1922, p. 401–407, figs. 260–263.
Zinnecker, 1935, p. 53–72, figs. 1–6.
Fritsch, 1935, p. 375–377, fig. 117, B, C.
Smith, 1938, p. 103–105, fig. 53; 1944, p. 72–74, pl. 9, figs. 2, 3; 1955, p. 101–104, fig. 53.
Egerod, 1952, p. 369–371, fig. 7.
Hustede, 1960, p. 19; 1964, p. 134–142, figs. 1–4.

Key to Species of Bryopsis

1. Thallus with erect branches pinnately branched; determinate branchlets (pinnules) abruptly constricted and unequally rounded at the point of insertion; branches usually more or less alternate throughout; chloroplasts usually elongate with several pyrenoids .... *B. corticulans,* p. 123
1. Thallus with erect branches pinnately branched; determinate branchlets (pinnules) gradually tapering and not appreciably rounded at point of insertion; branches in mature portion of thallus usually more or less alternate; chloroplasts spherical to ovoid, usually with one pyrenoid .... *B. plumosa,* p. 123

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*The recent discovery of a *Derbesia*-stage (*D. neglecta*) in the life history of *Bryopsis* (*B. halymeniae*) indicates that this generalization is not true for all species of *Bryopsis* (Hustede, 1964).

Bryopsis corticulans Setchell, *in* Collins, Holden and Setchell, 1899, No. 626.
Pl. 5, figs. A–H; pl. 6, figs. A–C.

Plants stout, 5–10 (–14) cm high, and coarse; dark green in colour in distal regions, paler green proximally; frequently with several erect axes from a common base. Each axis is more or less percurrent, up to (0.5–) 1 mm in diameter near the base and usually devoid of branches in the lower parts in the mature condition. The thallus is attached to the substratum by an irregularly branched rhizoidal system of branches 70–145 μ in diameter. The distichous branches are more or less alternately arranged throughout. Upper portion of axis, which is pinnately branched two to three times, is 150–350 μ in diameter. The ultimate branches decrease in length toward the tip of the branch, giving the thallus and branches a pyramidal appearance. Branches are abruptly rounded at the point of attachment to the main axes, and the ultimate simple branches reach a length of up to 950 μ and are 45–70 μ in diameter. In the younger branches the abaxial part of the constricted region usually bulges somewhat at the point from which, in older branches, short rhizoidal descending outgrowths arise. Older branches become separated from the main axes by septa at the constricted attachment region of the branch.

The chloroplasts vary from slightly ovoid to spindle-shaped and are up to 7 μ in width and 25 μ in length with one to six pyrenoids. The nuclei are spherical 7–8 μ in diameter with a conspicuous nucleolus.

The plants are unisexual. The gametes are produced near the apex of the axes in unmodified, determinate, simple branches which become separated by a septum from the main axes. Sexual reproduction is anisogamous by biflagellate gametes.

Vegetative reproduction by abscission of older branches with rhizoidal bases occurs.

References:

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Setchell and Gardner, 1903, p. 230 (in part as *B. hypnoides*); 1920*a*, p. 160, pl. 15, figs. 4, 5, pl. 27.
Collins, 1909*a*, p. 404; 1913, p. 106.
Smith, 1930, p. 231; 1938, p. 104, fig. 53; 1944, p. 73, pl. 9, fig. 3.
Fritsch, 1935, p. 376, fig. 117, B, C.
Dawson, 1945, p. 19.
Sanborn and Doty, 1947, p. 26.
Doty, 1947, p. 29.
Scagel, 1957, p. 62 (also in part as *B. hypnoides*).

Habitat. On rocks, shell, and old wood in the lower intertidal zone.

Type Locality. Pacific Grove, California.

Pacific Coast Distribution. Vancouver Island, British Columbia, to Mexico.

Bryopsis plumosa (Hudson) C. Agardh, 1822, p. 448.
Pl. 6, figs. D–G; pl. 7, figs. A–E.

Plants tufted, pinnately divided two or three times, profusely branched, with main axes erect, about 400 μ in diameter, more or less percurrent, 5–6 cm high; not conspicuously pyramidal in arrangement of branches and not usually naked near the base of the main axes; fastened to the substratum by a system of branched rhizoids; determinate branchlets about 115 μ in diameter and 2.5–3.5 (–3.8) mm long, longer and finer than in *B. corticulans,* and decreasing in length toward the tip of the branch. Branches distichously arranged, more or less opposite in position except near apex of main axes. Rhizoidal branches may arise from base of the lower branches. Chloroplasts 5–10 μ in diameter, spherical to ovoid with generally only one pyrenoid.

The gametangia are produced near the apex of the axes in unmodified, determinate, simple branches which become separated by a septum from the main axes.

Vegetative reproduction occurs by abscission of older branches with rhizoidal bases.

References:

Hudson, 1778, p. 571 (as *Ulva plumosa*).
Agardh, 1822, p. 448.
Harvey, 1849*a*, p. 194, pl. 24, fig. B, 1, 2; 1846, pl. 3; 1858, p. 31, pl. XLV, fig. A; 1871, pl. III.
Hauck, 1885, p. 471, fig. 208.
DeToni, 1889, p. 431.
Wille, 1890, p. 128, fig. 84.
Collins, Holden and Setchell, 1896, V (No. 227).
Tilden, 1900, IV (No. 371).
Collins, 1909*a*, p. 403 (in part as *B. hypnoides*), pl. XVII, fig. 153; 1913, p. 105 (in part as *B. hypnoides*).
Setchell and Gardner, 1920*a*, p. 161, pl. 14, figs. 1, 2; 1903, p. 230 (as *B. hypnoides*).
Hamel, 1928, p. 61, fig. 20C.
Newton, 1931, p. 97, fig. 64.
Fritsch, 1935, p. 376, fig. 117, A, D–F, H–K.
Levring, 1935, p. 15; 1937, p. 34.
Taylor, 1937, p. 97, pl. 7, figs. 1–3; 1957, p. 94, pl. 7, figs. 1–3.
Kylin, 1949, p. 66, fig. 64.
Chapman, 1956, p. 476, fig. 135.
Scagel, 1957, p. 63 (also p. 62, in part, as *B. hypnoides*).

Habitat. On rocks, shells, and old wood, and epiphytic on other algae in the lower intertidal zone.

Type Locality. Exmouth, Devon, England (*Ulva plumosa* Hudson).

Pacific Coast Distribution. Southern British Columbia to Central California.

The occurrence in this area of *Bryopsis hypnoides* Lamouroux (1809, p. 135, pl. 1, fig. 2, a, b,) and *B. plumosa* (Hudson) C. Agardh is based on several early records and herbarium specimens (*see* Scagel, 1957, p. 62, 63). The distinction between some of these specimens and *B. corticulans* Setchell is not clear-cut, and there is even some justification for considering the genus in this area as comprising one variable population referable to *B. corticulans*. However, I am inclined to agree with Setchell and Gardner (1920*a*, p. 161) that *B. corticulans* is a bona fide entity that should be distinguished from *B. plumosa,* rather than that the concept of the species *B. plumosa* should be broadened to include it. In the typical environment of *B. corticulans* on the open coast, the plant encountered in this area agrees well with the description (Collins, Holden and Setchell, 1899, XIII, No. 626) and the type (UC 98652). However, in more protected areas, and when the plants are younger, the specimens encountered approach the characteristics typical for *B. plumosa* (but not so slender as *B. hypnoides*).

That there is such variability inherent in the population has been clearly demonstrated also in culture studies of local specimens. Thus, none of the plants found in this area (or the specimens previously referred to from this area as *B. hypnoides*—CAN 128 and UC 98668 from Victoria, British Columbia, and UC 392842 from Muir Creek, British Columbia, are *B. plumosa;* UC 98670 and 98669 from English Camp, San Juan Island, Washington, V 1230 and CAN 1197 from Brandon Island, British Columbia, are *B. corticulans*) are believed referable to *B. hypnoides* Lamouroux. Although the distichous habit of branching typical of both *B. corticulans* and *B. plumosa* is at times somewhat irregular, no plants having a typical polystichous habit, as is typical for *B. hypnoides*, have been seen in this area. The species of *Bryopsis* present in Japan have not been thoroughly studied, but specimens of one entity, which is much coarser (UBC 7325 from Mira, Chiba Prefecture), are probably referable to *B. corticulans* (although this species has not previously been recorded from Japan) rather than to *B. plumosa*. However, other plants occurring in Japan (UBC 7595 from Handa, Aichi Prefecture) are referable to *B. plumosa* and compare closely to the type (CN).

KEY TO THE GENERA OF CHLOROPHYCEAE

1. Plant body non-motile, unicellular or multicellular 2
1. Plant body motile, unicellular, usually biflagellate or quadriflagellate (often in spray pools near high-tide mark) 37
   2. Growing superficially on various substrata, including rocks and various organisms 3
   2. Growing in or upon other algae or within the shells of molluscs 31
3. Thallus a branched or unbranched filament, with or without transverse walls 17
3. Thallus not composed of freely branched filaments 4
   4. Thallus forming a thick, spongy encrusting layer, consisting of a densely compacted network of microscopic, branched, multinucleate, non-septate filaments .... CODIUM, p. 117
   4. Thallus not forming a spongy encrusting layer 5
5. Thallus erect, cylindrical, tubular, or markedly flattened 7
5. Thallus hemispherical to globose 6
   6. Thallus oval or globose, one-celled, with penetrating rhizoids (growing usually on encrusting coralline algae and found chiefly on the exposed coast) .... HALICYSTIS, p. 114
   6. Thallus multicellular with cells irregularly distributed through a colourless, mucilaginous matrix .... COLLINSIELLA, p. 22
7. Thallus markedly flattened 8
7. Thallus cylindrical, branched or unbranched 12
   8. Thallus one cell in thickness 9
   8. Thallus two cells in thickness 10
9. Thallus foliaceous, less than 1 cm broad, cells usually arranged in groups of four or multiples (growing often on rocks coated with droppings from sea birds near high-tide mark) .... PRASIOLA, p. 66
9. Thallus more than 1 cm broad (saccate when young) .... MONOSTROMA, p. 33
   10. Base of plant consisting of several creeping, branched filaments fused together into a basal disc from which several narrow (1–3 mm broad), unbranched, erect axes arise; erect axes frequently somewhat swollen .... BLIDINGIA, p. 41
   10. Base of plant not composed of a filamentous disc from which several erect axes arise 11
11. Thallus a markedly flattened plate of two cell layers with no open space between .... ULVA, p. 57
11. Thallus tubular at maturity, slender or inflated, with wall one-cell layer in thickness, sometimes markedly flattened toward the apex .... ENTEROMORPHA, p. 44
   12. Thallus cylindrical, usually unbranched 13
   12. Thallus cylindrical and branched 15

13. Base of plant consisting of several creeping, branched filaments fused together into a basal disc from which several erect, narrow (1–3 mm broad), unbranched erect axes arise; erect axes frequently somewhat flattened and swollen .... BLIDINGIA, p. 41

13. Base of plant not composed of a filamentous disc from which several erect axes arise 14

14. Thallus hollow or tubular, slender or inflated, often flattened at the apex, wall one cell in thickness .... ENTEROMORPHA, p. 44

14. Thallus a solid cylinder constricted at intervals ROSENVINGIELLA, p. 69

15. Thallus dichotomously branched, branches more than 5 mm in diameter, consisting of a densely compacted spongy network of microscopic, non-septate, multinucleate filaments .... CODIUM, p. 117

15. Thallus consisting of a single, branched, tubular cell or branched, non-septate, multinucleate filament (without transverse walls), not organized in a spongy network 16

16. Branching profuse with radially, bilaterally, or pinnately arranged determinate branchlets arising from erect indeterminate axes..... BRYOPSIS, p. 122

16. Unbranched or sparingly branched; where branched, branching is irregular, unilateral, or more or less dichotomous with no differentiation in habit between axis and branchlets .... DERBESIA, p. 111

17. Filaments unicellular, tubular, without transverse walls 18

17. Filaments with transverse walls 19

18. Branching profuse with radially, bilaterally, or pinnately arranged determinate branchlets arising from erect more or less indeterminate axes .... BRYOPSIS, p. 122

18. Unbranched or sparingly branched; where branched, branching is irregular, unilateral, or more or less dichotomous with no differentiation between axis and branchlets .... DERBESIA, p. 111

19. Filaments entangled in mats that are frequently free-floating; filaments unbranched or restricted to short lateral branches 20

19. Filaments sessile, not bent and entangled with one another; filaments branched or unbranched 22

20. Filaments with cells symmetrically placed in double rows; forming entangled masses in tide pools and lagoons .... PERCURSARIA, p. 63

20. Filaments uniseriate; occasionally 2 or 3 cells in width in an otherwise uniseriate filament 21

21. Filaments unbranched; cells with a single, coarse, parietal, reticulate chloroplast .... LOLA, p. 75

21. Branching restricted to a few short lateral branches (occasionally unbranched) .... RHIZOCLONIUM, p. 72

22. Chloroplast a transverse band almost encircling the cell; short, uninucleate cells; filaments unbranched with a basal holdfast cell ..... ULOTHRIX, p. 26

22. Chloroplast not a transverse band 23

23. Filaments abundantly branched; adjacent branches united in rope-like strands by means of short, unbranched, narrow, sometimes almost colourless recurved branchlets, or by abundant simple or branched rhizoidal filaments .... SPONGOMORPHA, p. 94

23. Filaments not united in rope-like strands 24

24. Filaments with cells symmetrically placed in double rows; forming entangled masses in tide pools and lagoons .... PERCURSARIA, p. 63

24. Filaments uniseriate; occasionally 2 or 3 cells in width in an otherwise uniseriate filament 25

25. Filaments repeatedly branched 26

25. Filaments unbranched or restricted to a few short lateral branches or rhizoidal branches 27

26. Cells in filament multinucleate with a single, parietal, reticulate chloroplast or numerous discoid chloroplasts .... CLADOPHORA, p. 85

26. Cells in filament uninucleate with a cup-shaped chloroplast which is lobed at one end .... PRASINOCLADUS, p. 24

27. Filaments unbranched except for short rhizoidal branches serving for attachment; cells with a single, stellate, axial chloroplast ...... SCHIZOGONIUM, p. 65
27. Filaments unbranched or restricted to a few short lateral branches; filaments with or without differentiated basal cell or cells 28
    28. Filaments unbranched with differentiation of basal attachment cell(s) 29
    28. Filaments unbranched (or with a few short lateral branches without differentiation of basal cell(s)); usually in entangled masses 30
29. Basal cell several times longer than cells in upper part of filament; several short rhizoids arise from basal cell forming holdfast ...... CHAETOMORPHA, p. 82
29. Basal cell not more than double length of cells in the upper part of filament; attachment by basal holdfast and rhizoidal supports developing from a few neighbouring cells ...... UROSPORA, p. 76
    30. Filaments unbranched; coarse, parietal, reticulate chloroplast ...... LOLA, p. 75
    30. Branching restricted to a few short lateral branches (occasionally unbranched) ...... RHIZOCLONIUM, p. 72
31. Growing within other algae 32
31. Growing within shells of molluscs; sometimes in soft rock or wood 35
    32. Thallus unicellular 33
    32. Thallus a branched filament 34
33. Cell with a basal stipe or pedicel; ovoid to clavate in shape ...... CODIOLUM, p. 104
33. Cell without a basal stipe; oval or spherical in shape ...... CHLOROCHYTRIUM, p. 102
    34. Thallus a profusely branched filament, forming an anastomosing network; cells with a parietal chloroplast ...... INTERNORETIA, p. 32
    34. Thallus forming small patches on the membranes of supporting host; an irregularly branched filament with branches radiating from a common centre; single, laminate, parietal chloroplast with one or more pyrenoids; hairs and setae absent ...... ENTOCLADIA, p. 30
35. Within shells of molluscs (sometimes epiphytic); cells in creeping, branched filaments; cells bearing from one to three simple, long, colourless hairs ...... PHAEOPHILA, p. 31
35. Within shells of molluscs, chalky rock, or wood; cells in filaments without hairs 36
    36. Irregularly branched, creeping filaments with one to several simple or bifurcate rhizoids on the underside ...... GOMONTIA, p. 107
    36. Irregularly branched, interwoven, multinucleate, non-septate filaments, usually irregularly swollen and lobed, particularly at ends of branches ...... OSTREOBIUM, p. 3
37. Plants with a definite homogeneous cell wall 38
37. Plants naked with an elastic periplast but without a definite cell wall 39
    38. Cell quadriflagellate, slightly to distinctly flattened, and ovoid ...... TETRASELMIS, p. 18
    38. Cell biflagellate, uncompressed 42
39. Cells more or less identical in shape in lateral and ventral views 40
39. Cells usually compressed, differing in lateral and ventral views 41
    40. Surface of motile cell with longitudinal keels or ridges; flagella of equal length and anterior in position ...... STEPHANOPTERA, p. 15
    40. Surface of motile cell without longitudinal ridges, flagella of equal length and anterior position ...... DUNALIELLA, p. 15
41. Flagella unequal or subequal; one simple, one with mastigonemes (tinsellated); pyrenoid present ...... THALASSOMONAS, p. 17
41. Flagella unequal or subequal; both flagella simple; pyrenoid absent ...... ANISOMONAS, p. 17
    42. Cell subglobular, pyriform or ovoid, and cylindrical, with wall extending to form an acute posterior horn and four others arranged in a cruciate manner about the anterior edges ...... BRACHIOMONAS, p. 19
    42. Cell ovoid to globular, not with horns or lobes ...... CHLAMYDOMONAS, p. 20

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GLOSSARY

abaxial, the side away from the axis.
abscission, detachment.
accessory pigment, a non-chlorophyll pigment, such as phycobilins, carotenes, and xanthophylls.
acute, sharply and distinctly pointed, but not drawn out.
adaxial, the side toward the axis.
adjacent, situated near.
aggregation, an accumulation of cells or individuals usually without any set pattern of organization.
akinete, a non-motile spore resulting from the metamorphosis of an ordinary vegetative cell, usually developing a thick wall.
alternate, on opposite sides of an axis, but not at the same plane; not opposite.
alternation of generations, the succession of cytologically different phases in the life history of a sexually reproducing plant.
amorphous, without definite form or regular arrangement of parts or cells.
anastomosing, communicating by cross-connections.
anatomical, with reference to structure, usually at the microscopic level.
angular, with divergent parts.
anisogamous, having anisogamy.
anisogamy, sexual reproduction where the gametes are usually both motile, but differ in size, the female gamete being larger than the male.
annular, in a ring or circle.
anterior, at the front end.
antheridium (pl. *antheridia*), a male reproductive organ which produces gametes (usually motile).
apex (pl. *apices*), the distal end.
apical, at or referring to the apex.
apical cell, a cell situated at the apex of a thallus or its branches and specialized for initiating growth.
apiculate, terminating in a short, sharp point.
aplanospore, a non-motile spore (mitospore or meiospore) resulting from division of one cell into a number of daughter cells (spores); arrested zoospores which have skipped the motile phase.
arcuate, bent or curved like a bow.
areole, arranged or divided into distinct areas.
attenuate, narrow and tapering gradually to a point.
autospore, an aplanospore which, at maturity, assumes the form (in miniature) of the parent cell.
autotrophic, capable of manufacturing its own organic food.
axial, located in the centre.
axile, with reference to the axis or centre.
axis (pl. *axes*), the longitudinal (imaginary) line along which the parts of a plant are arranged.

biflagellate, possessing two flagella.
bifurcate, divided into two branches; twice forked.
bilateral, having two matching sides.
bipartition, division into two parts.
biseriate, in two rows.
bisexual, the condition in which the same thallus produces both male and female gametes (sometimes referred to as homothallic or monoecious).
blade, a flattened, leaf-like part of the thallus.
blunt, ending in a rounded form, not sharp.
branchlet, a small branch.
bullate, having a blistered or puckered appearance.
bullation, a blister or pucker.

calcified, encrusted with lime (calcium carbonate).
callose, a cellulose-like organic base of the cell wall in some plants.
carotenes, accessory pigments, usually yellowish to orange in colour.
cellulose, the chief organic base (carbohydrate) of the cell wall.
centripetal, developing from the outside toward the centre.
chlorophyll, the green colouring matter of plants.
chloroplast, a plastid containing the green photosynthetic pigments (chlorophylls).

circinate, coiled in a ring.

clavate, club-shaped, thickened toward the apex.

colonial, a group of cells resulting from cell division, attaining definite size and form and usually with some division of labour.

compacted, closely packed or pressed together.

compound, not simple, an aggregation of similar parts.

compressed, flattened.

concave, hollowed out, saucer-like.

confluent, merging, or passing by degrees one into the other.

constricted, drawn together or contracted.

contorted, twisted or bent.

contractile vacuole, small vacuoles (or cavities) within the cell, which usually increase and decrease in size rhythmically.

coralline algae, the calcified encrusting and articulated red algae.

cortex, the portion of the thallus external to the medulla and internal to the epidermis.

cortical, referring to the cortex.

crisped, curled.

cruciate, in two planes at right angles; cross-shaped.

cubical, having the form of a cube.

cuneate, triangular or wedge-shaped.

cylindrical, elongated with a circular outline in transverse section.

cytological, referring to the intracellular characteristics with particular reference to the nuclear condition and chromosome complement (1n or 2n).

cytoplasm, the protoplasm of the cell.

demarcated, clearly defined, with definite boundaries.

dendroid, tree-like in form or branching.

determinate, incapable of developing beyond a limited or definite extent.

dichotomously branched, branched by repeated forking.

dichotomy, a forking into two similar parts.

dilated, swollen, expanded or enlarged.

diploid, having a 2n chromosome complement.

disciform, shaped like a disc; flat and circular.

discoid, in the form of a disc (flat and circular).

dissected, deeply divided into a number of segments.

dissimilar, unlike parts.

distal, at the free end; remote from the point of attachment.

distichously, arranged in two vertical rows or ranks.

distromatic, two cell-layers in thickness.

divaricate, branching so as to form an obtuse angle above and an acute angle below.

divergent, separating from one another.

dormancy, state of quiescence or inactivity.

elastic, capable of changing in shape and returning to the original form.

ellipsoid, shaped like an ellipse (oblong and with rounded ends).

elliptical, referring to an ellipse (oblong with rounded ends).

elongate, greater in length than in breadth.

embedded, immersed or surrounded.

encrusting, covering with a layer or crust.

endophyte, a plant growing within another plant, parasitic or non-parasitic.

endophytic, growing within the tissue of another plant, parasitically or non-parasitically.

endozoic, growing within an animal or a part of an animal.

entire, smooth.

enveloped, enclosed within.

epidermal, relating to the outermost cover or layer of cells.

epidermis, the superficial cover or layer of cells.

epiphyte, a non-parasitic plant growing on the surface of another plant.

epiphytic, growing superficially on the surface of another plant, but not parasitically.

epizoic, growing on the surface of a living animal, parasitic or non-parasitic.

equidistant, the same distance from two sides (central in position).

excentric, one-sided, out of centre, asymmetrical.

excentrically, with reference to excentric.

extramatrical, outside of the matrix.

eyespot, a pigmented (orange or red) light-sensitive body.

fastigiate, branches clustered, more or less parallel with the supporting axis.

fenestrate, irregularly perforate.

fertile, with reproductive structures.

filament, a branched or unbranched row of cells joined usually in simple series; thread-like.

filamentous, in the form of a filament.

filiform, hair-like or thread-like.

flaccid, soft and limp.

flagellated, with flagella or whip-like processes.

flagellation, referring to the type of flagella.

flagelliform, slender like a whip, usually tapering.

flagellum (pl. *flagella*), the hair-like swimming organ(s) by which a cell, such as a zoospore, moves in the water.

flexuous, winding.

foliaceous, leaf-like, broad and flat.

foliose, broad and flat, leaf-like.

fragmentation, breaking apart (of the thallus).

freely, not attached laterally.

fruiting, bearing mature reproductive stages.

furled, rolled or curled up.

furrow, a longitudinal depression or deep striation.

fusiform, thick in the centre and tapering to each end.

gametangial, referring to the gametangium.

gametangium (pl. *gametangia*), a sex organ in which a gamete or gametes are formed.

gamete, a unisexual protoplasmic body which usually fuses with another to give rise to a zygote.

gametogenesis, at formation of gametes.

gametophyte, the gamete-producing generation in the life history of a plant.

germinate, to undergo the first act of development (of a zoospore or zygote).

germination, the act of germinating.

germling, a juvenile phase in an early post-germination phase.

glaucous, powdery white or greyish.

globose, nearly spherical.

globular, more or less approaching a sphere in shape.

granules, a non-specific cytoplasmic particle.

gregarious, clustered or grouped closely together.

haematochrome, an orange to red carotenoid pigment.

hair, a narrow filament arising from the surface of the thallus.

haplobiontic, having a multicellular or conspicuous 1n phase and a 2n phase represented only by a zygote.

haploid, having the 1n chromosome complement.

hemispherical, with reference to one-half of a sphere.

heterodynamic, in flagellation, referring to different types of action or movement in each of two flagella.

heterokont, having two flagella unequal in length.

heteromorphic, having morphologically different 1n and 2n phases in a life history.

heterotrophic, unable to carry on photosynthesis; obtaining organic food as saprophytes or parasites.

holdfast, the disc-like structure by which an alga is usually fastened to the substratum.

homogeneous, uniform.

horn, a pronounced projection, like the horn of an animal.

host, the plant providing the substratum for a parasite (also often used when the attached individual is epiphytic).

hyaline, translucent or colourless.

hypha (pl. *hyphae*), fungus (or fungus-like) filaments.

hyphal, referring to hypha.

invagination, a depression.

investment, a covering.

indeterminate, of unlimited growth, repeating the habit of the parent system.

inflated, swollen or dilated.

insertion, point of attachment of a part to its support.

intercalary, not apical, between the apex and the base.

intercellular, between the cells.

intertidal, with reference to the zone between high and low tide levels.

interwoven, growing amongst each other (usually of filaments).

intramatrical, within a matrix.

isodiametric, having equal dimensions or diameters.

isodynamic, in flagellation, referring to the same type of action or movement in each of two flagella.

isogamous, having isogamy.

isogamy, sexual reproduction in which the male and female gametes are morphologically similar, and usually both motile.

isomorphic, having the 1n and 2n phases in a life history morphologically similar.

keel, a ridge, like the keel of a boat.

lacerated, torn or irregularly cleft.

lamellate, made up of layers.

lamellose, made up of layers.

laminate, plate-like.

laminated, made up of layers.

lanceolate, narrow, tapering to each end (or broad at one end).
lateral, situated at or near the side.
laxly, loosely.
life cycle, the course of development from one point and back to a similar phase in a life history.
linear, several times longer than broad.
lobed, a rounded division of a plant or part.
locomotor, with reference to organs (such as flagella) of movement.
longitudinal, in the direction of the length.
lubricous, slippery.
lumen, a cavity or space bounded by walls (or cells).

macroscopic, visible by the naked eye.
marginal, at the edge or margin.
mastigonemes, the hair-like processes present on a tinsellated flagellum.
matrix, a surrounding or enveloping amorphous acellular substance.
medianly, along the middle.
medulla, the central, usually looser core of tissue of a multicellular alga.
medullary, pertaining to the medulla.
meiosis, reduction division.
meiospore, a spore arising as a result of meiotic division of a cell of the 2n phase.
meiotically, referring to meiosis.
membrane, a thin, pliable, semi-transparent layer.
membranous, like a membrane.
metamorphose, to change in form (and usually function).
microscopic, visible only under high magnification.
mitospore, a spore arising as a result of mitotic divisions in or metamorphosis of a vegetative cell of a 1n or 2n phase.
mitotic, referring to mitosis.
moniliform, segmented so as to resemble a string of beads.
monostromatic, of a single layer of cells.
morphological, referring to form or structure.
mucilagination, turning to jelly-like consistency, softening.
mucilaginous, slimy or jelly-like (usually referring to the pectic or pectic-like substances between the cells and/or enveloping the outer portion of the plant).
multicellular, made up of more than one (usually many) cells.
multiflagellate, having many flagella.
multilayered, made up of several (many) layers.
multinucleate, containing more than one (usually many) nucleus(i).
multiseriate, with several series or rows of cells.

naked, without a discrete cell wall.
nannoplankton, unicellular autotrophic or heterotrophic organisms of extremely small size (passing through the finest silk meshes, usually of the order of 10 μ or less in maximum diameter).
non-filamentous, not in the form of a filament.
non-flagellated, without flagella.
non-septate, without cross walls or septa.

obligate, necessary or essential.
oblique, at an angle, slanting.
oblong, having length much greater than width, with sides nearly parallel.
obspherical, rounded or spherical at the distal end.
ontogenetic, referring to the development of an individual in its various stages.
oogamous, having oogamy.
oogamy, sexual reproduction in which a male gamete (usually a motile sperm) fertilizes a large non-motile egg.
oogonium (pl. *oogonia*), a female reproductive organ containing one to several eggs.
orbicular, a flat body approximately circular in outline.
organ, a part of the thallus specialized for some function (in the algae usually with reference to reproductive structures).
ovate, oval in outline.
ovoid, shaped like an egg.

palisade-like, in the form of a palisade (elongated surface cells).
palmelloid, embedded in mucilaginous, jelly-like mass.
papilla, a small protuberance.
parasitic, growing on and obtaining food from another organism, the host.
parenchyma, a group of thin-walled, more or less isodiametric cells.
parenchymatous, made up of parenchyma.
parietal, borne on or near the side walls.
parthenogenesis, development of a gamete (usually an egg) without fertilization.
parthenogenetic, referring to parthenogenesis.

pectic, with reference to pectin; also the general term applied to the substance which forms an amorphous intercellular and outer transparent, jelly-like layer of the thallus.

pectinate, with branches restricted to one side, close-set like the teeth of a comb.

pedicel, a narrow, stem-like support.

percurrent, running through the entire length.

perennial, extending growth over a period of more than one year.

perforate, full of holes.

perforated, filled with holes.

peripheral, around the periphery or outside.

periplast, a hyaline envelope or membrane enveloping the cell.

phase, stage (in life history).

photosynthetic, capable of photosynthesis.

phototactic, response to the direction of light.

phytoplankton, free-swimming or free-floating unicellular algae.

pigmentation, pigment composition.

pigmented, having pigments.

pinnate, with determinate branches on each side of a common axis; feather-like.

pinnately, in a pinnate fashion.

pinnule, the determinate branches (secondary pinnae) in pinnate branching.

pitting, small depressions or thinner portions in cell walls.

plankton, free-swimming or free-floating, usually microscopic, assemblage of aquatic organisms.

plastid, a protoplasmic body or granule, usually differentiated as a centre of chemical activity.

polar, at the pole (or end).

polygonal, having many angles.

polystichous, borne in many series along several radii.

polystromatic, made up of many cell layers.

posterior, at the back.

processes, outgrowths.

procumbent, lying or creeping along the substratum.

profusely, liberally.

proliferation, an outgrowth or offshoot.

proliferous, bearing offshoots.

prostrate, lying along the substratum.

protoplasm, the living substance of the cell.

protoplast, a unit of protoplasm, the cell (usually without the cell wall).

proximally, referring to the attached end.

pseudodichotomous, having the general appearance of dichotomy.

pseudoparenchymatous, a tissue giving the appearance of a parenchyma.

pulvinate, cushion-like.

pyramidal, pyramid-shaped.

pyrenoid, a starch-forming centre embedded in the chloroplast, usually clearly distinguished when stained with iodine.

pyriform, pear-shaped.

quadrate, squarish.

quadriflagellate, with four flagella.

radially, arising from a centre along several radii.

recurved, curved or bent back.

refractive, having optical qualities such that light is markedly reflected or refracted, making the object or body appear bright.

regenerate, vegetative development from a dormant or old part of a thallus.

reniform, kidney- or bean-shaped.

repeatedly, occurring again and again.

reserve, accumulated storage (usually carbohydrate) which can be utilized for respiration.

reticulate, in the form of a net.

reticulum, a network.

rhizoid, a filamentous root-like attachment organ.

rhizoidal, in the form of a rhizoid.

rhizome, a prostrate stem-like portion of a thallus.

ruffled, with a pronounced wavy margin.

saccate, sac-like.

sculpturing, ornamented in relief.

secund, with branches along one side only.

sedentary, attached.

septum (pl. *septa*), transverse partition(s).

sessile, without a stalk.

seta (pl. *setae*), a bristle-shaped structure or cell.

sheath, an enclosing layer.

simple, unbranched.

skein, a rope-like intertwined mass of filaments.

solitary, single.

sparingly, not frequent.

specific, referring to the species.

sperm, a motile male gamete.

spermatophyte, a seed plant (phanerogam).

spherical, in the shape of a sphere or globe.

spindle-shaped, circular in transverse section, but elongate, having a broader diameter in the centre and tapering toward each end.
spine, a sharp process.
sporangium (pl. *sporangia*), a unicellular reproductive cell which endogenously produces spores.
spore, a motile or non-motile reproductive cell which germinates and grows into a new individual.
sporophyte, the 2n phase of a plant.
spray pool, a pool of water high in the intertidal zone or in the supratidal zone.
starch, a carbohydrate reserve stored by plants.
stellate, star-shaped.
stephanokont, having flagella in a crown or transverse row toward the end.
sterile, not fertile.
stipe, the erect, stem-like portion of a thallus.
stipitate, with a stipe.
stolon, a prostrate stalk-like portion.
stratified, in layers.
subapical, not quite at the apex.
subbasal, next to the base.
subdichotomous, not quite dichotomous.
subequal, almost, but not quite equal.
subglobular, almost spherical.
subquadrate, not quite square.
subterminal, not quite at the end.
subtidal, below the lowest low-tide level.
superficial, on the surface.
sympodial, referring to an axis which appears simple, but remains so because at each division of the thallus only one of the branches develops.

taxon, a taxonomic category with undefined limits, usually subgeneric.
terete, cylindrical, rounded in sectional view, usually tapering.
terminal, borne at the free end.
thallus, a plant body—a primitive plant body without true roots, stems, or leaves.
tinsellated, having the flagellum covered with short spine-like or hair-like processes (mastigonemes).
tissue, a group of cells similar in shape and function.
trabeculae, cross-connections.
transversely, at right angles to the longitudinal axis.
trichotomous, divided into three parts.
truncate, more or less rectangular, as though cut off at the end.
tuberculate, with irregular warty outgrowths.
tubular, in the form of a tube.
tufted, in small bunches.
turgid, having turgor, swollen, but not with gas.
turgor, turgidity.

ultimate, occurring in the last order.
uncompressed, not flattened.
undifferentiated, not specialized (not distinguishable from the vegetative condition, although sometimes slightly different in size).
undulate, wavy.
unicellular, composed of one cell.
uniflagellate, having one flagellum.
unilateral, occurring on one side only.
uninucleate, having only one nucleus.
uniseriate, occurring in one row or series.
unisexual, the condition in which the gametes arise on separate thalli (sometimes referred to as heterothallic or dioecious).
unmasked, not obscured.
utricle, a bladder-shaped cell or process.

vegetative, not specialized or reproductive.
ventral, on the lower surface.
vesicle, a bladder.
vesicular, like a vesicle.
vesiculate, in the form of a vesicle.

whiplash, long and slender, like the lash of a whip (with reference to a flagellum).
whorl, an arrangement of parts in a circle around an axis.

xanthophyll, an accessory pigment, usually yellowish in colour.

zoosporangia, sporangia which produce zoospores.
zoospore, a motile non-gametic (1n or 2n) reproductive cell bearing flagella; it may be a mitospore or a meiospore.
zygospore, a zygote usually with a heavy wall, and generally a resting stage.
zygote, the first (and sometimes only) 2n cell following union of two gametes.

PLATES 1 TO 49

PLATE 1

Derbesia marina (Lyngbye) Kjellman

A. Branching habit of plant in erect portion, X 50.
B. Basal rhizoidal holdfast, X 115.
C. Branch tip, X 1080.
D. Longitudinal view in section showing arrangement of chloroplasts and nuclei, X 1080.
E. Septum at base of branch, X 500.
F. Portion of plant showing branch originating below septum, X 500.
G. Immature sporangia (upper one not yet cut off; lower one cut off by septum), X 115.
H. Mature sporangium with spores, X 500.
I. Motile zoospore, X 2000.

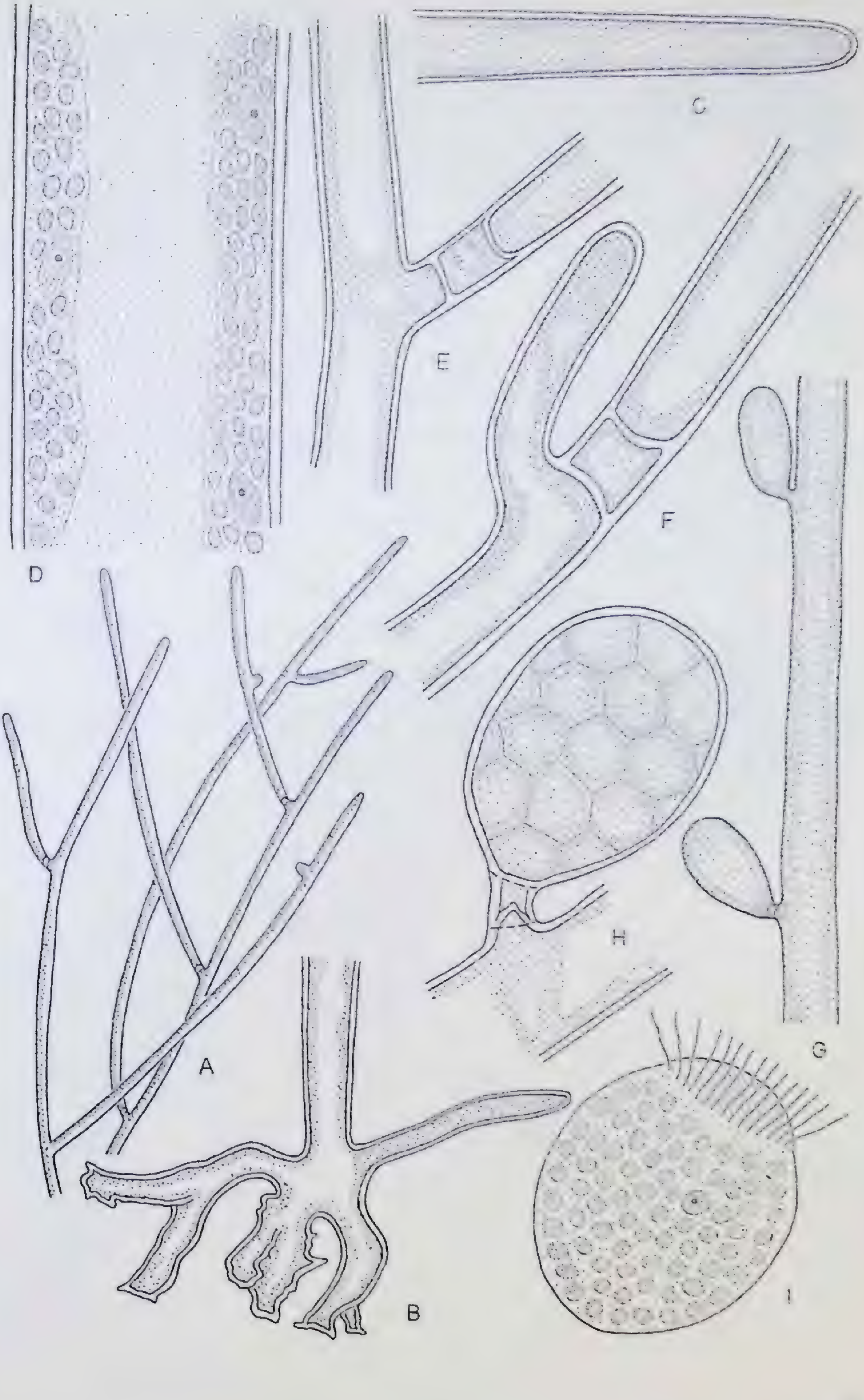
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PLATE 2

Halicystis ovalis (Lyngbye) Areschoug

A. Habit of fertile plants showing discharge pores prior to liberation of gametes, X 5.
B. Female gamete, X 2000.
C. Male gamete, X 2000.
D. Germinating zygote, X 1080.
E. Germling, 5 days old, X 1080.
F. Germling, 7 days old, X 500.

Codium fragile (Suringar) Hariot

G. Habit of plant showing erect branches arising from cushion-like base, X 0.5.
H. Utricle with two gametangia, X 75.
I. Apical region of utricle with colourless hair cell attached, X 75.
J–L. Stages in formation and septation of colourless hair cell, X 375.
M. Apical region of utricle showing sharper mucron with the inner portion of the wall invaginated, X 375.

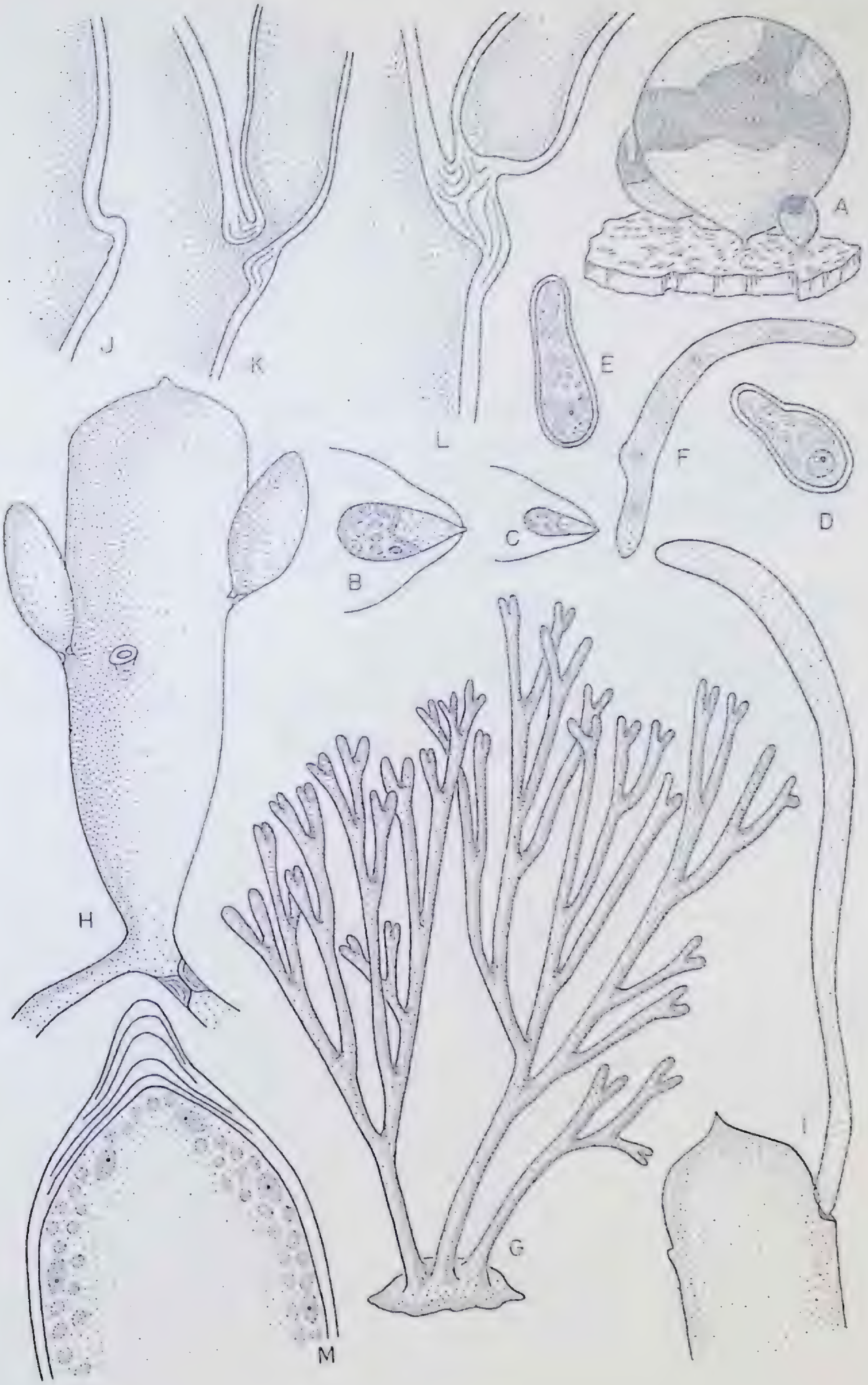
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PLATE 3

Codium fragile (Suringar) Hariot

A. Apical portion of utricle with blunt mucron and inner wall not invaginated (sectional view showing chloroplasts and nuclei), X 375.
B. Mature gametangium with gametes, X 375.
C. Apical portion of utricle from type material from Japan (Textor), X 375.

Codium ritteri Setchell and Gardner

D. Habit of plant (side view), X 0.5.
E. Habit of plant (top view), X 0.5.
F. Surface view of plant showing group of utricles, X 2.
G. Group of utricles showing branching habit, X 30.
H. Detail of branch base showing septum and initiation of rhizoid from new branch, X 25.
I. Detail of utricle showing basal rhizoids and septum, X 25.
J. Portion of rhizoid, X 75.

PLATE 3

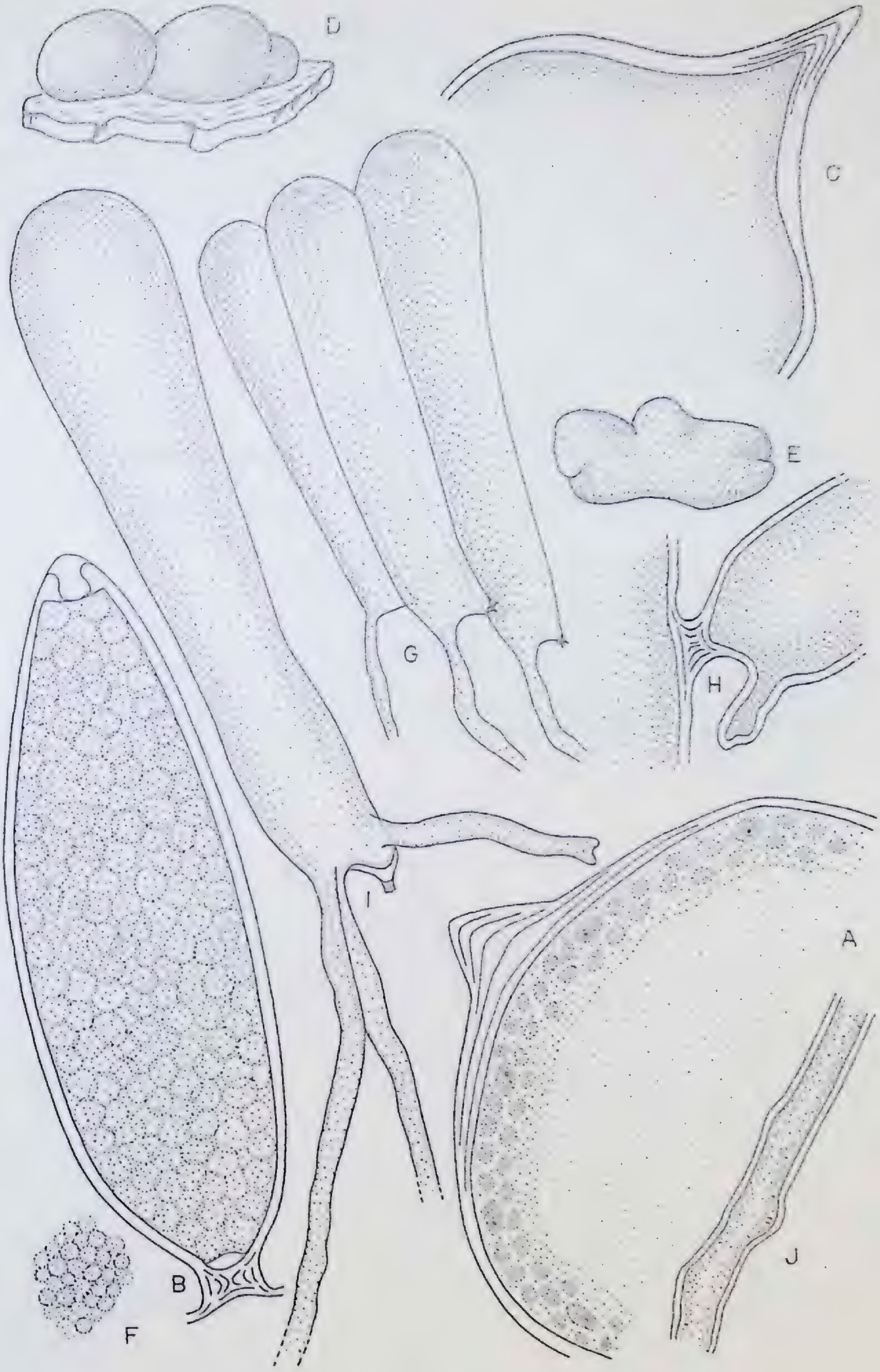

PLATE 4

Codium ritteri Setchell and Gardner

A. Apical portion of utricle showing depression at apex and modification in inner surface of wall, X 115.
B. Enlarged view showing detail of a portion of the wall near the apex of the utricle, X 1080.

Codium setchellii Setchell and Gardner

C. Habit as seen from upper surface, X 0.25.
D. Group of utricles showing branching habit, X 115.
E. Group of utricles showing branching habit and one gametangium, X 25.
F. Portion of rhizoid, X 115.
G. Apical region of utricle (sectional view showing chloroplasts and nuclei), X 500.
H. Mature gametangium with gametes, X 375.

PLATE 4

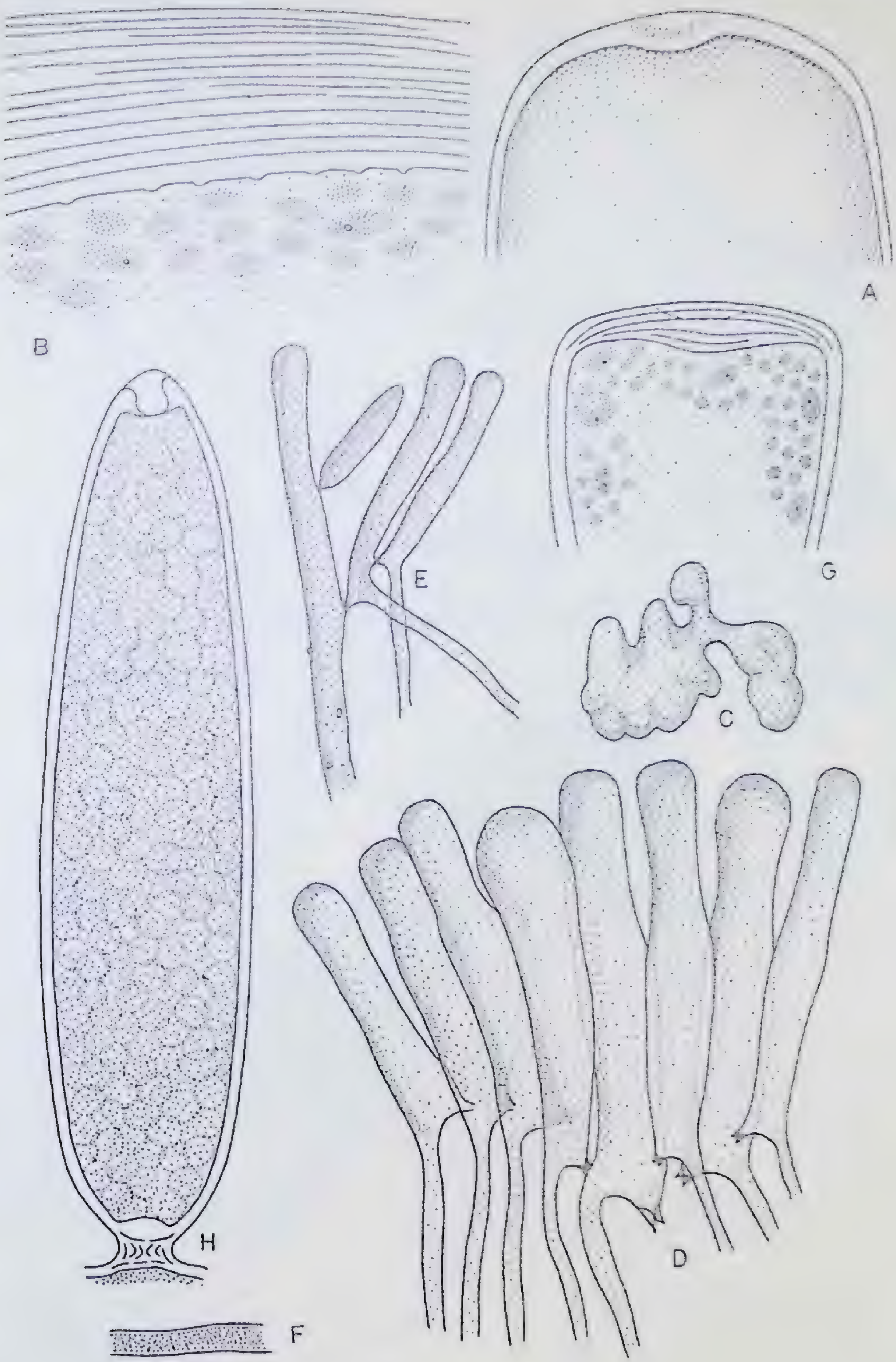

PLATE 5

Bryopsis corticulans Setchell

A. Habit, X 2.5.
B. Rhizoidal holdfast, X 50.
C. Portion of main axis showing branching habit, X 50.
D, E. Insertion of branches on main axis showing stages in initiation of rhizoidal bases, X 75.
F. Sectional view of young branch arising near the apex of the main axis, X 115.
G. Sectional view of branch arising some distance from apex of main axis, showing septum, X 115.
H. Sectional view of branch arising a few branches back of the apex of the main axis, X 75.

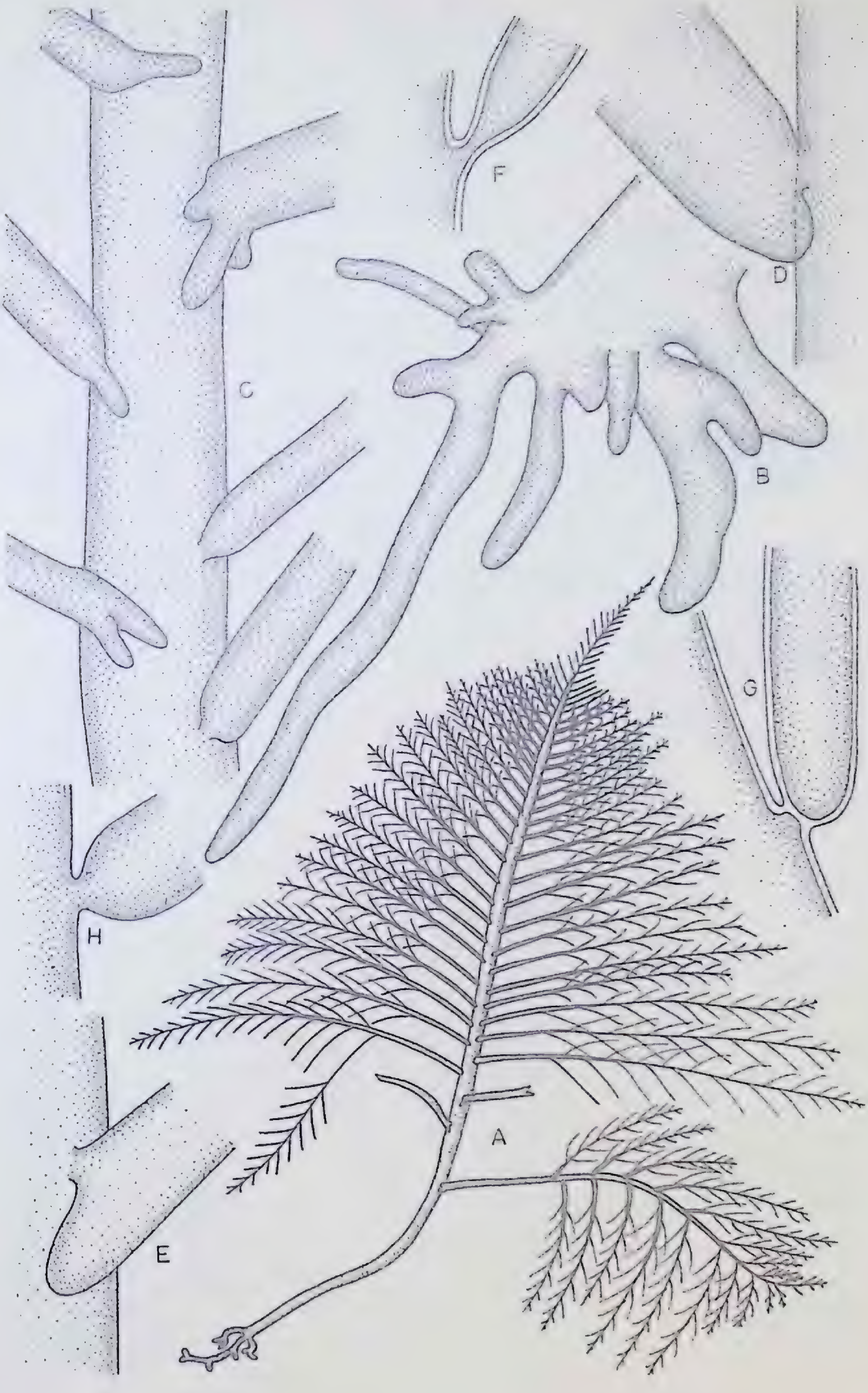
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PLATE 6

Bryopsis corticulans Setchell

A. Chloroplasts, X 1080.
B, C. Mature branches near base of main axis showing stages in development of the rhizoidal bases, X 115.

Bryopsis plumosa (Hudson) C. Agardh

D. Apical region of main axis showing branching habit, X 75.
E. Subapical region of main axis showing branching several millimetres back of apex, X 75.
F. Rhizoidal holdfast of main axis, X 115.
G. Chloroplasts, X 1080.

PLATE 6

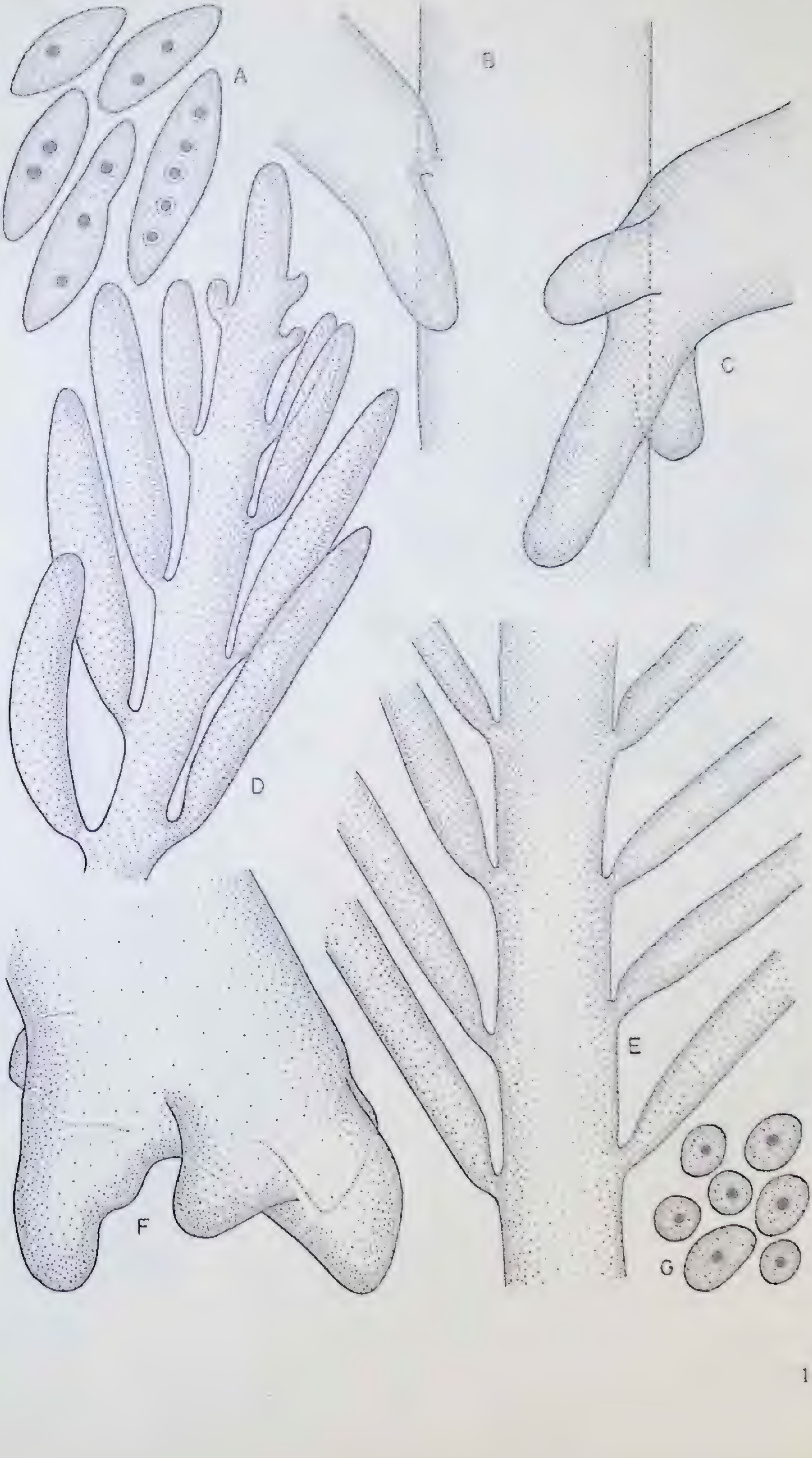

PLATE 7

Bryopsis plumosa (Hudson) C. Agardh

A. Portion of main axis some distance from the base showing insertion of branch with complete connection, X 375.
B. Portion of main axis near the base showing insertion of branch and septum, X 375.
C. Portion of plant several millimetres from apex of the main axis showing branch insertion, X 375.
D. A portion of the plant showing insertion of the male gametangium, X 115.
E. A portion of the plant showing detail of septum at point of insertion of the male gametangium, X 500.

Codiolum gregarium Braun

F. Habit of several plants, X 150.
G. Vegetative condition of the thallus, X 230.
H, I. Fertile plants, X 500.
J. Quadriflagellate zoospore, X 1080.
K–M. Stages in germination of zoospores and early stages of filamentous phase (*Urospora*), X 1080.

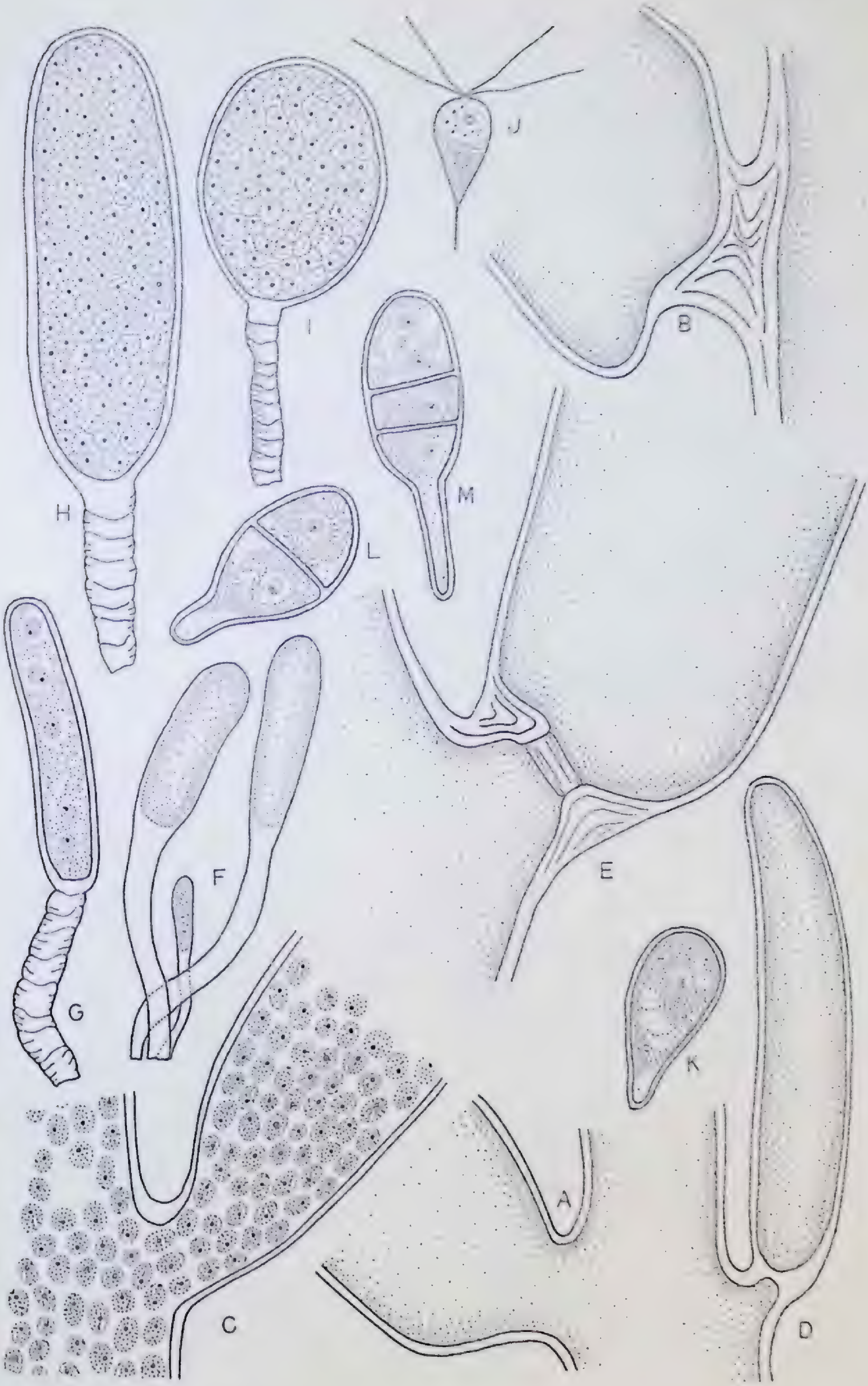
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PLATE 8

Codiolum gregarium Braun (*Urospora* stage)

A, B. Stages in development from germinating zoospore, X 1080.

Codiolum gregarium Braun

C. Mature plant in the vegetative condition, X 230.
D. Habit, X 230.
E. Mature sporangium, X 500.

Codiolum petrocelidis Kuckuck

F. Habit showing plant among filaments of *Petrocelis*, X 1080.
G. A single plant showing cellular detail and rhizoidal holdfast, X 1080.

PLATE 8

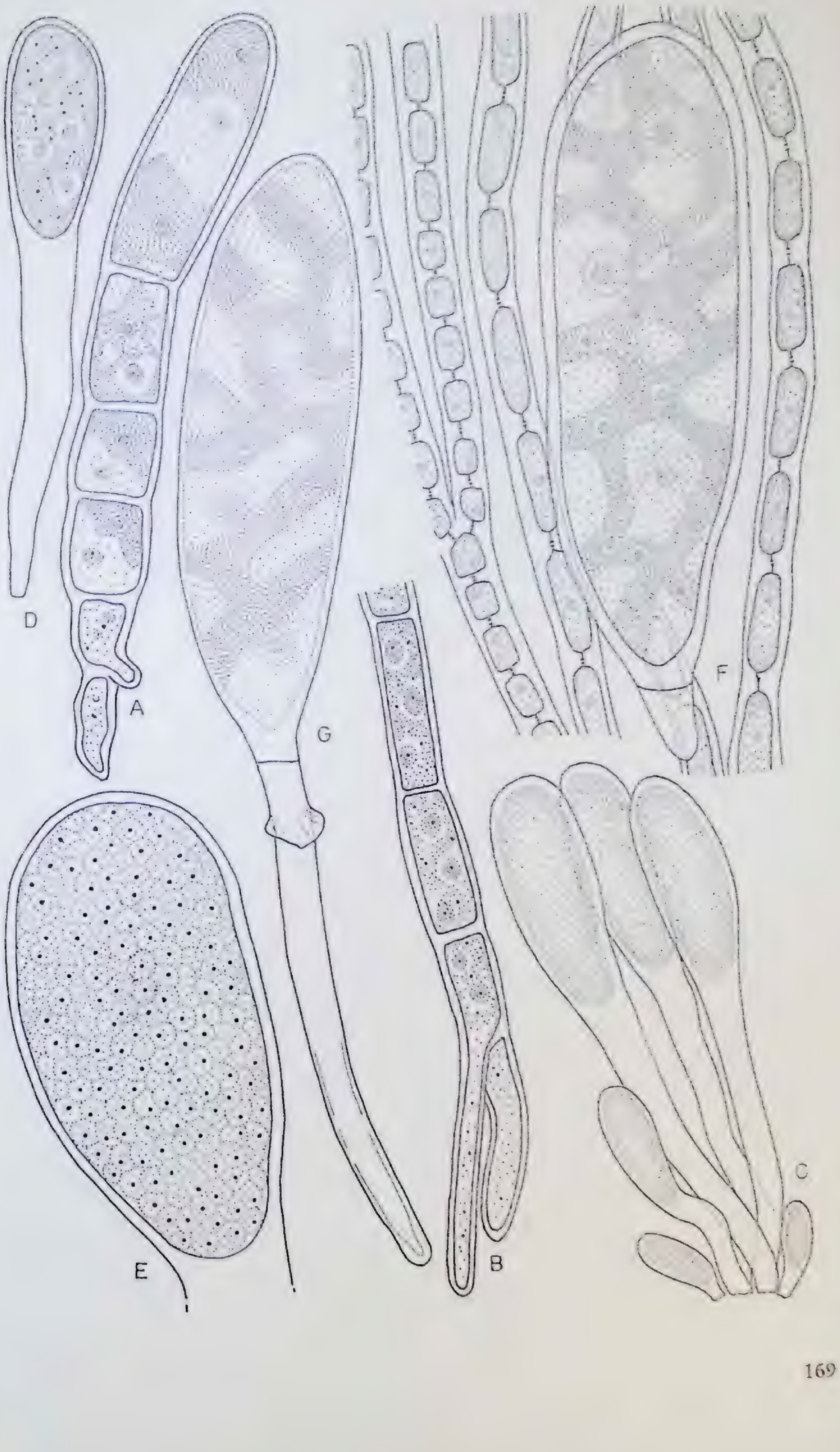

PLATE 9

Chlorochytrium inclusum Kjellman

A. Habit, showing endophytic plant among the cells of the host, *Schizymenia pacifica;* host cells shown with pit-connections, X 720.

Chlorochytrium porphyrae Setchell and Gardner

B. Habit, endophytic in *Porphyra lanceolata,* X 720.
C, D. Vegetative condition, X 1080.
E, F. Stages in maturation of the gametangium, X 1080.
G. Mature gametangium, X 1080.
H. Gametangium, almost empty, showing discharge pore, X 1080.

PLATE 9

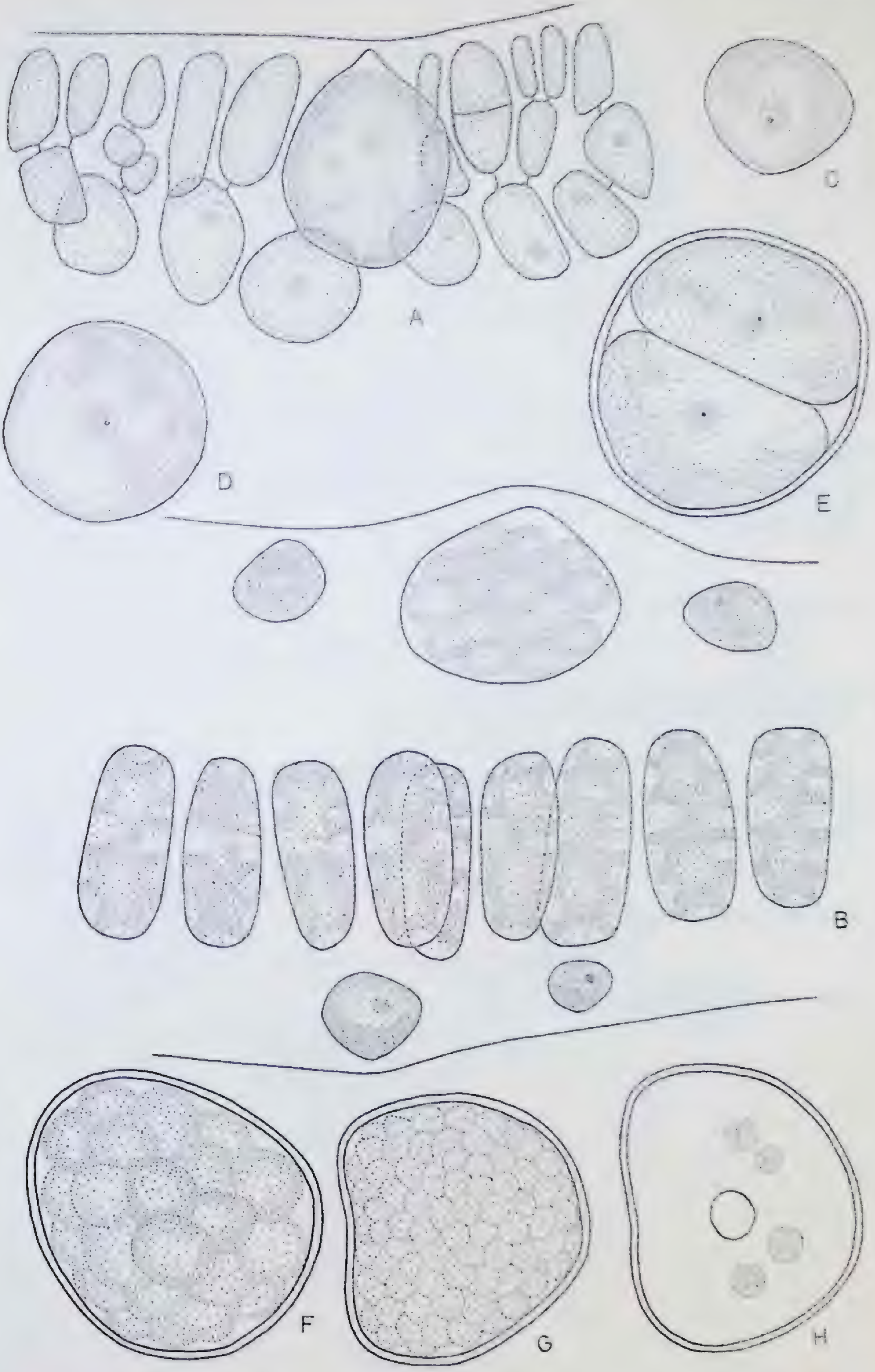

PLATE 10

Gomontia polyrhiza (Lagerheim) Bornet and Flahault

A. Vegetative filament, X 650.
B, C. Stages in development of young sporangium; B, X 500; C, X 1080.
D. Mature sporangium, X 1080.
E. Quadriflagellate zoospore, X 3000.

Dunaliella salina (Dunal) Teodoresco

F. Vegetative condition, X 3500.

Stephanoptera gracilis (Artari) G. M. Smith

G. Vegetative condition, lateral view, X 1650.
H. Vegetative condition, polar view, X 1650.

Brachiomonas submarina Bohlin

I. Vegetative condition, lateral view, X 2500.
J. Vegetative condition, polar view, X 2500.

Anisomonas astigmatica Scagel and Stein

K. Vegetative condition, X 3000.

Thalassomonas exurgens Butcher

L. Vegetative condition, X 2500.

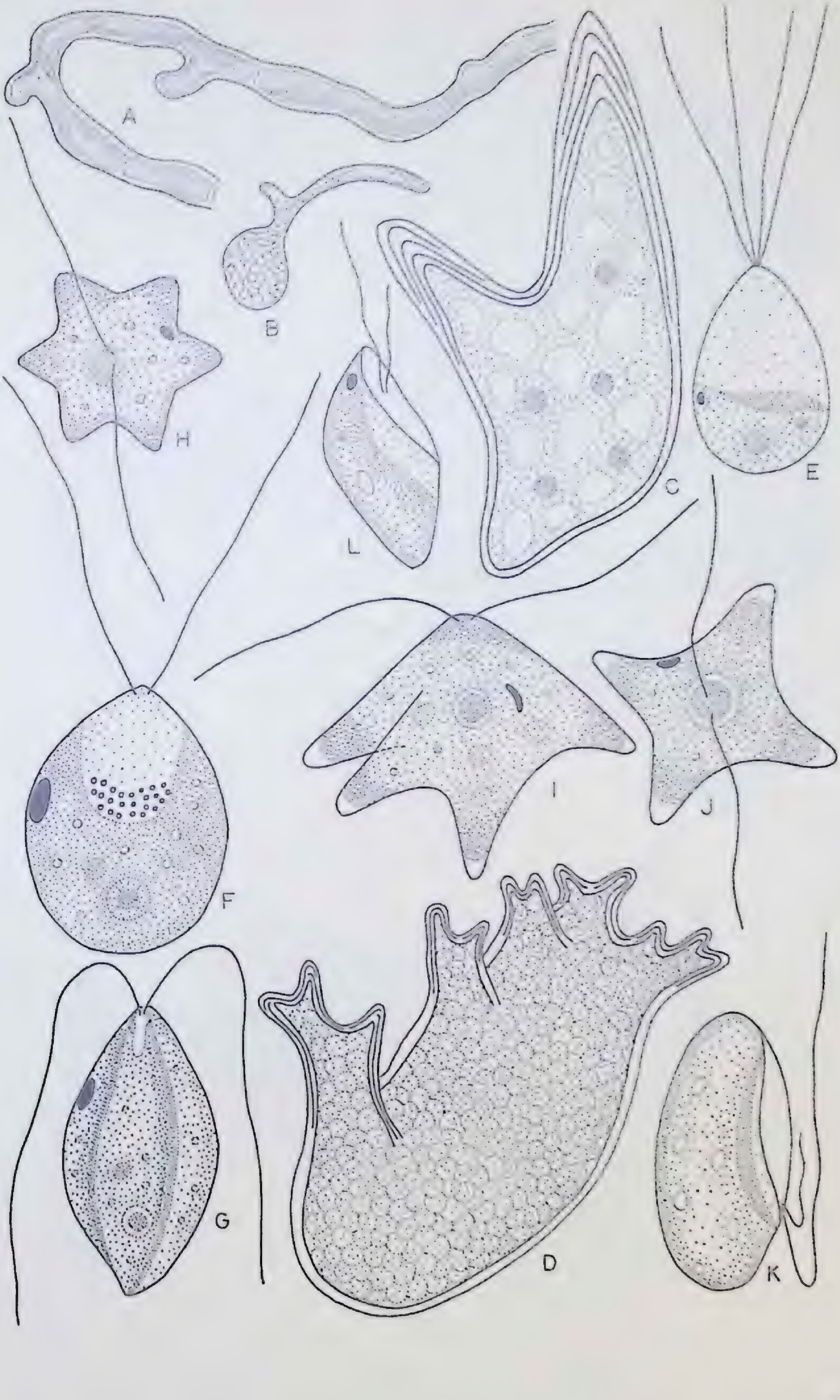
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PLATE 11

Chlamydomonas pulsatilla Wohlenweber

A. Vegetative condition, X 1650.
B. Cell containing zoospores, X 1650.

Tetraselmis maculata Butcher

C. Vegetative condition, lateral view, X 5000.
D. Vegetative condition, lateral view, X 5000.
E. Cell undergoing division, X 5000.

Prasinocladus lubricus Kuckuck

F. Vegetative condition of thallus, X 1080.
G. Terminal portion of a branch showing cell division, X 1080.
H. Zoospore, X 1080.

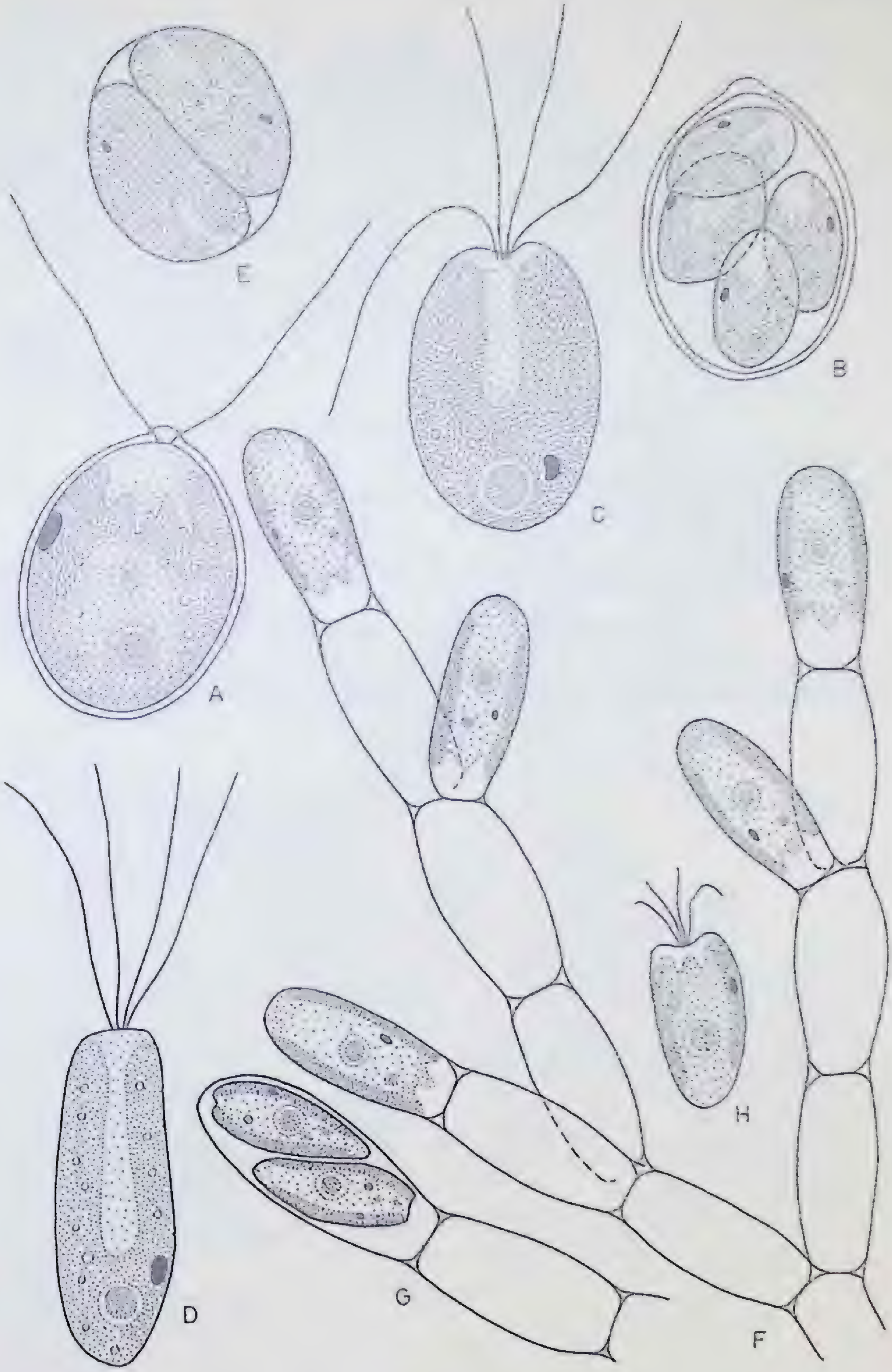
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PLATE 12

Collinsiella tuberculata Setchell and Gardner

A. Habit view, X 7.5.
B. Sectional view at the surface showing vegetative cells and two gametangia, X 720.
C. View of cells from the surface, X 720.
D. Gamete, X 1440.
E. View of squashed preparation from near the surface showing mucilaginous sheath surrounding cells, X 720.

Schizogonium murale var. *uniseriatum* Jao

F. Basal portion of a filament showing rhizoidal branches, X 720.
G. Portion of filament showing initiation of rhizoidal branches, X 720.

PLATE 12

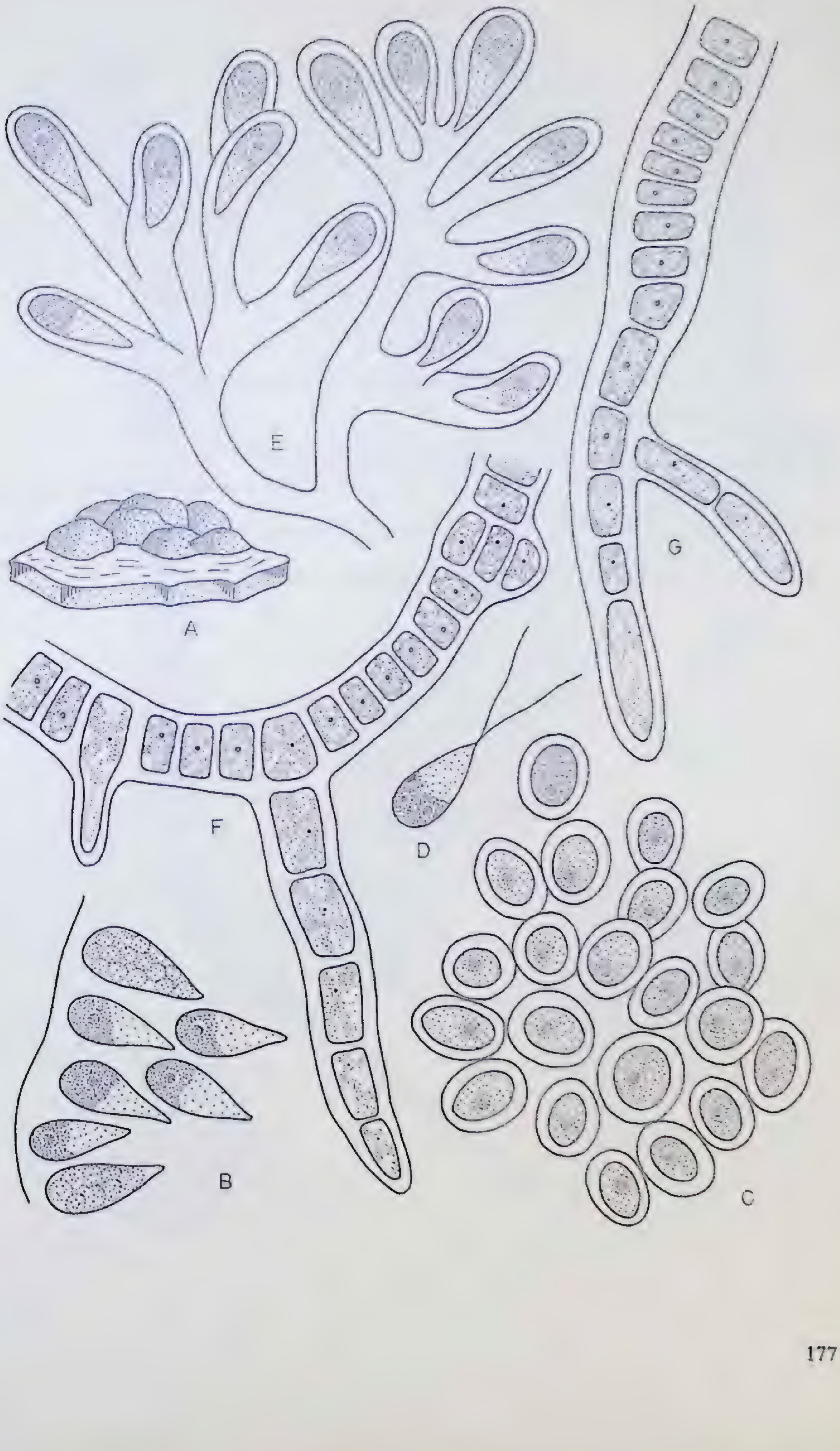

PLATE 13

Rosenvingiella constricta (Setchell and Gardner) Silva

A. Surface view of thallus, X 150.
B. Surface view of portion of thallus becoming multiseriate, X 1080.
C. Basal portion of thallus showing rhizoidal character, X 720.
D. Cross-sectional view of portion of thallus in early stages of parenchymatous division, X 720.
E. Cross-sectional view of mature portion of thallus showing parenchymatous habit, X 720.
F. Surface view of cells in mature portion of thallus, X 1080.

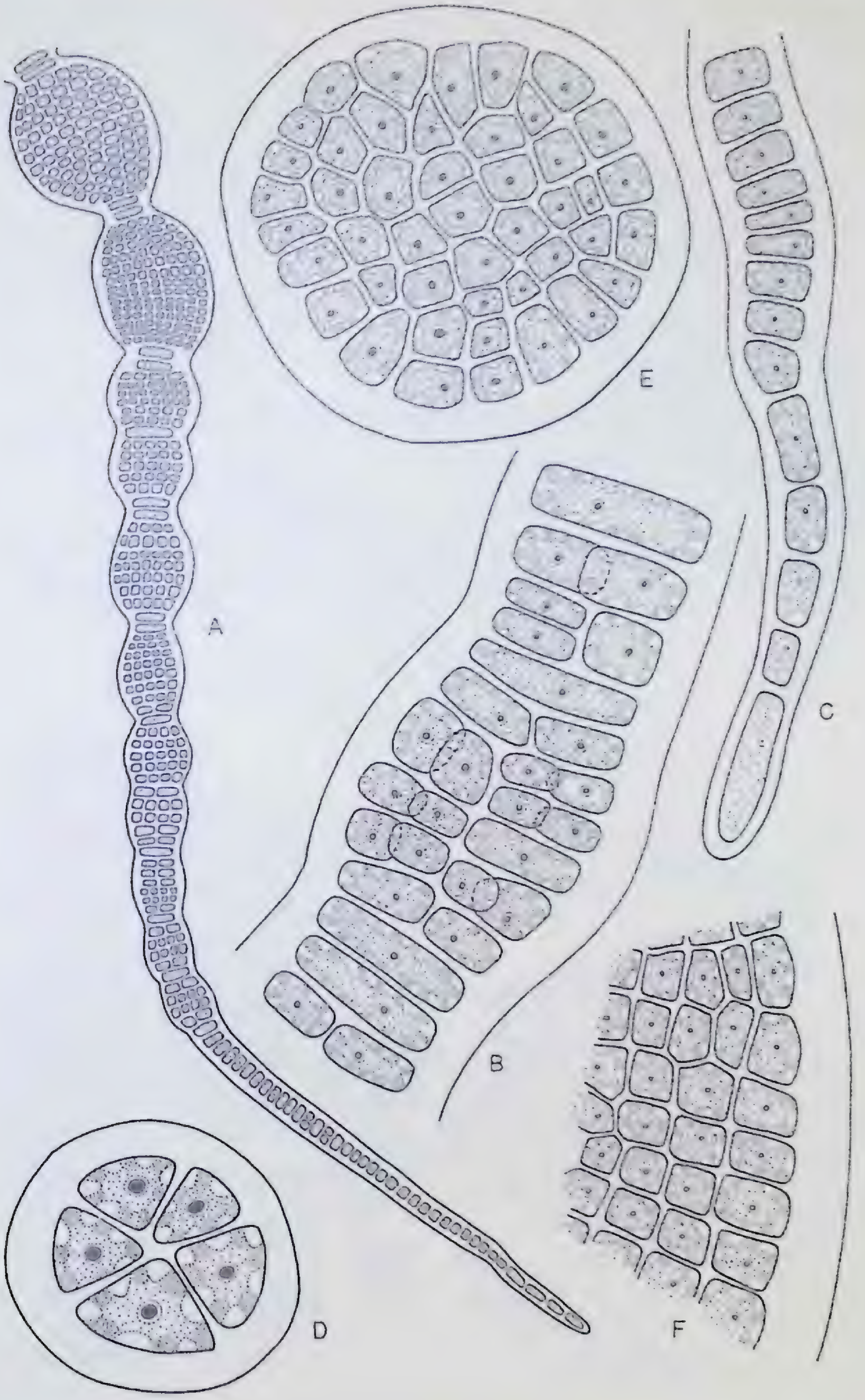
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PLATE 14

Prasiola meridionalis Setchell and Gardner

A–C. Outline sketches of young plants, X 150.
D. Habit sketch of group of plants, X 32.
E. Sketch of basal portion of a mature plant, X 32.
F. Surface view of thallus showing arrangement of cells in distal portion of mature plant in the vegetative condition, X 720.
G. Surface view of thallus in fertile portion of plant showing an akinete, X 1080.

PLATE 14

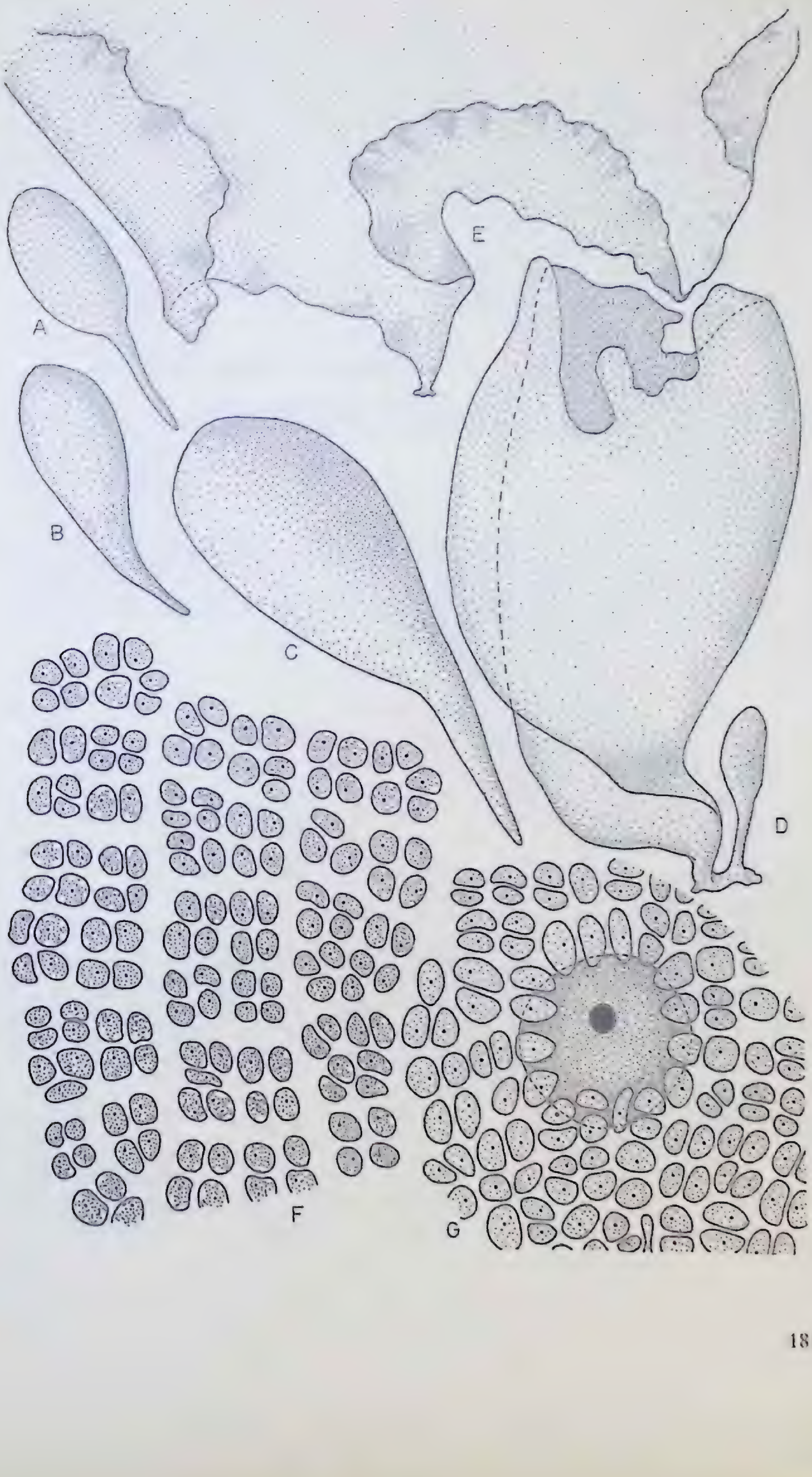

PLATE 15

Prasiola meridionalis Setchell and Gardner

A. Section in fertile portion of thallus showing an akinete, X 1080.

B, C. Sections in fertile portions of thallus showing formation of gametes and aplanospores, X 1080.

D. Sperm, X 1080.

E. Egg, X 1080.

F. Zygote, X 1080.

G, H. Early stages in development of juvenile thallus from zygote, X 1080.

I. Basal portion of a young plant showing transition from uniseriate basal to parenchymatous distal portion of the plant, X 720.

J. Basal portion of a mature plant showing irregular arrangement of basal cells of blade and multiseriate stipitate region, X 375.

PLATE 15

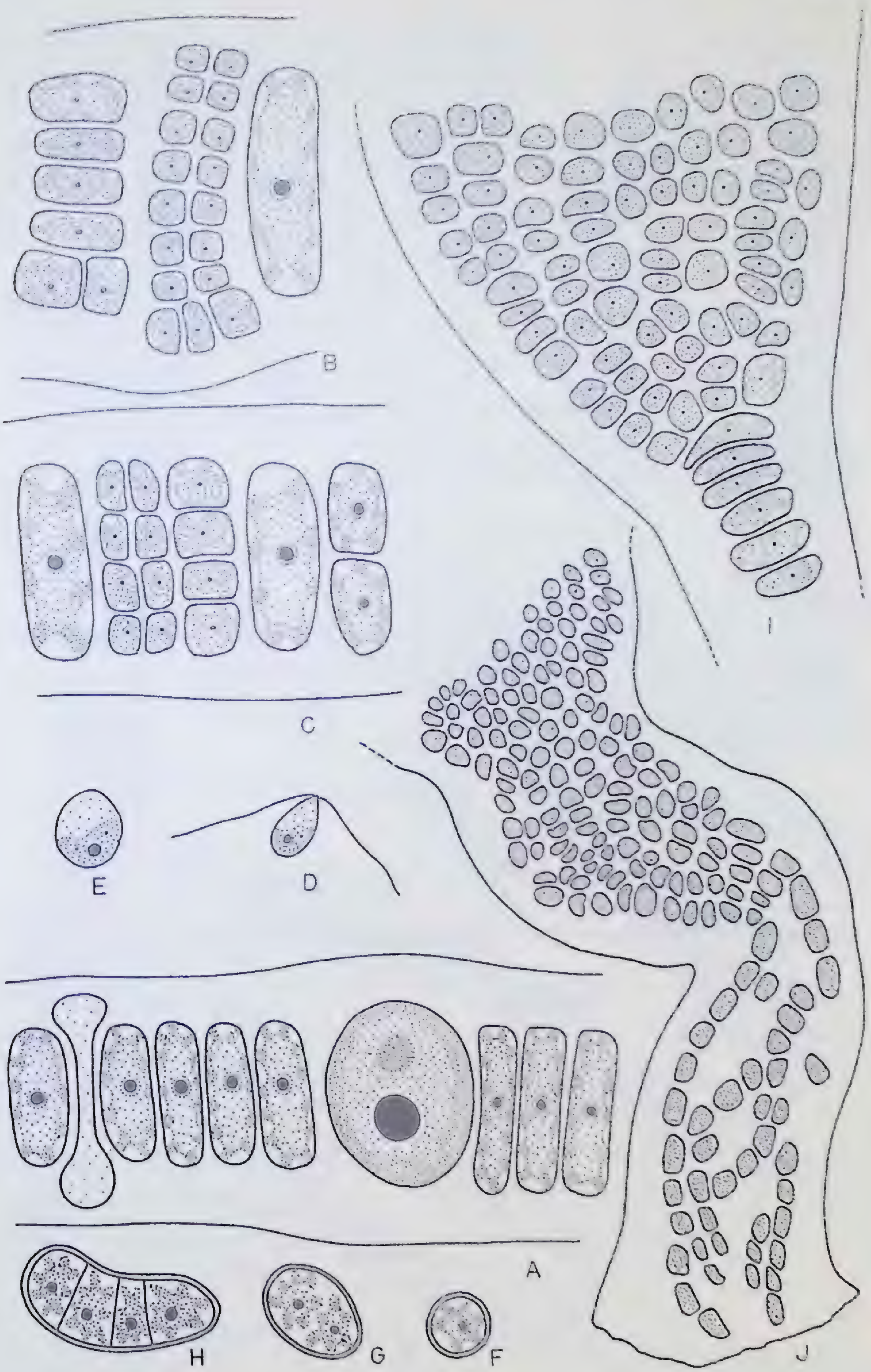

PLATE 16

Prasiola meridionalis Setchell and Gardner

A. Uniseriate juvenile plant, X 720.
B. Juvenile plant, showing initiation of parenchymatous distal portion of the thallus, X 720.

Ulothrix flacca (Dillwyn) Thuret

C. Juvenile plant, X 1080.
D. Vegetative condition of thallus, X 1080.
E. Fertile portion of filament showing sporangia; some with zoospores, others from which zoospores have all or nearly all escaped, X 1080.
F. Portion of filament from which all zoospores have escaped showing position of discharge pore, X 1080.
G. Aplanospores, X 1080.
H. Quadriflagellate zoospores, X 1080.

Ulothrix implexa Kützing

I, J. Vegetative condition of thallus, X 1080.

Ulothrix laetevirens (Kützing) Collins

K. Juvenile plant, X 1080.
L, M. Vegetative condition of plant showing branching characteristics, X 750.

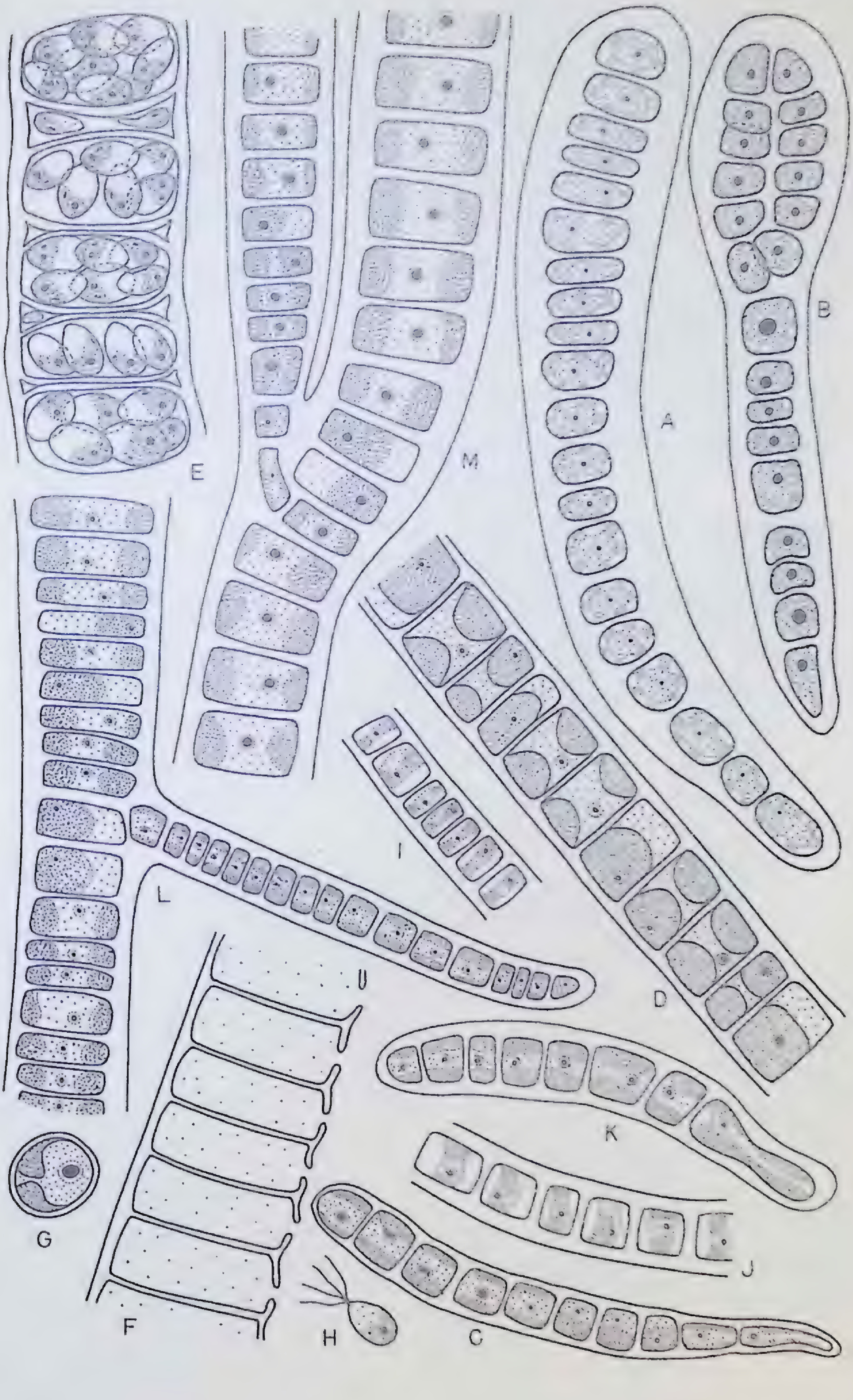
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PLATE 17

Internoretia fryeana Setchell and Gardner

A. Habit of thallus growing amongst cells of *Smithora*, X 1080.

Phaeophila polymorpha Jao

B. Portion of the filamentous thallus showing hairs, X 1080.

Entocladia viridis Reinke

C. Portion of the thallus showing branching habit, X 1080.

Percursaria percursa (C. Agardh) Bory

D. Portion of the thallus showing biseriate arrangement of cells. X 500.

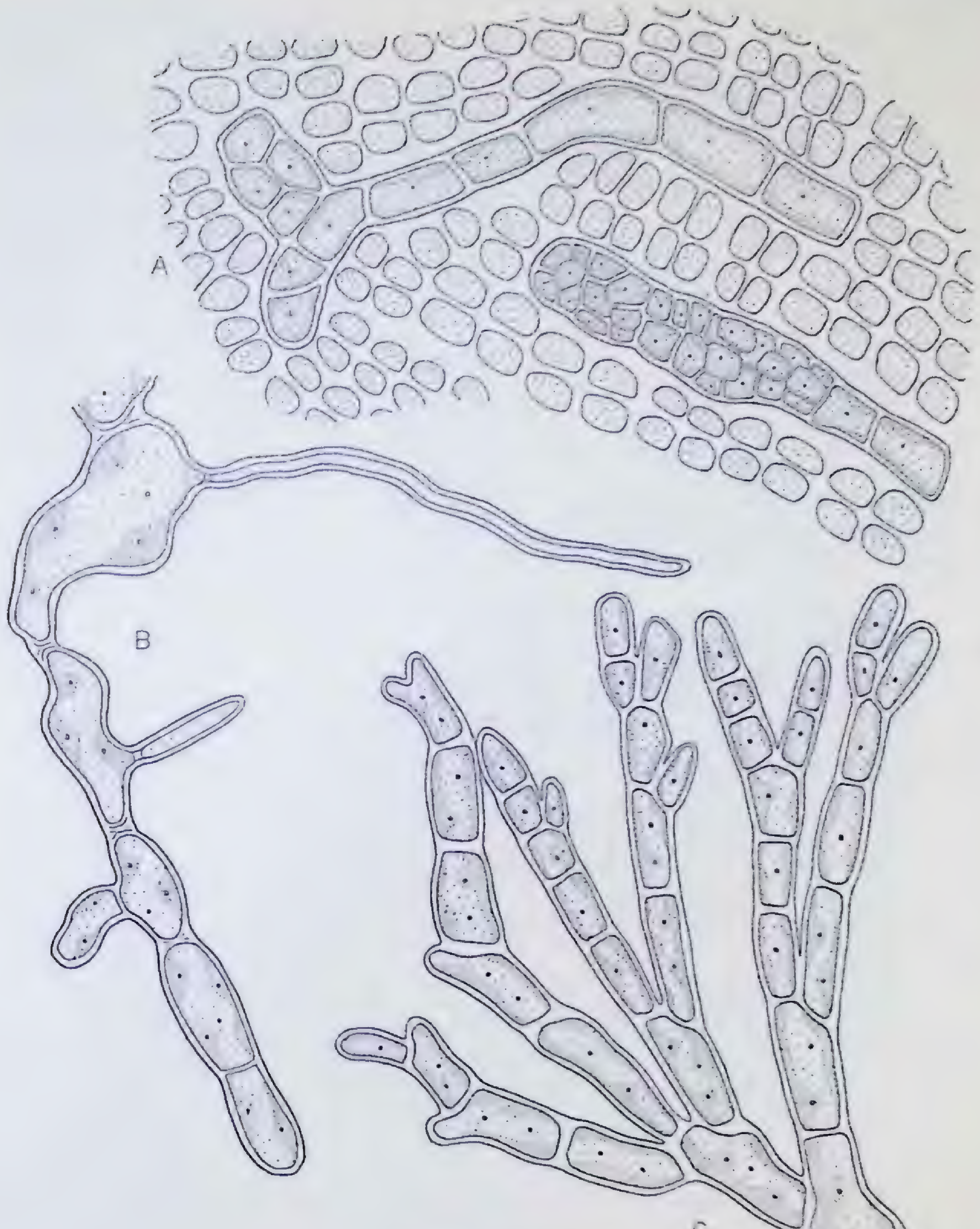
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PLATE 18

Monostroma zostericola Tilden

A. Surface view of thallus, X 720.
B. Habit of plants growing on leaf of *Phyllospadix*, X 2.
C. Section of thallus, X 1080.

Monostroma fractum Jao

D. Habit of plant, X 0.5.
E. Section of thallus, X 1080.

Monostroma arcticum Wittrock

F. Section of thallus, X 1080.

PLATE 18

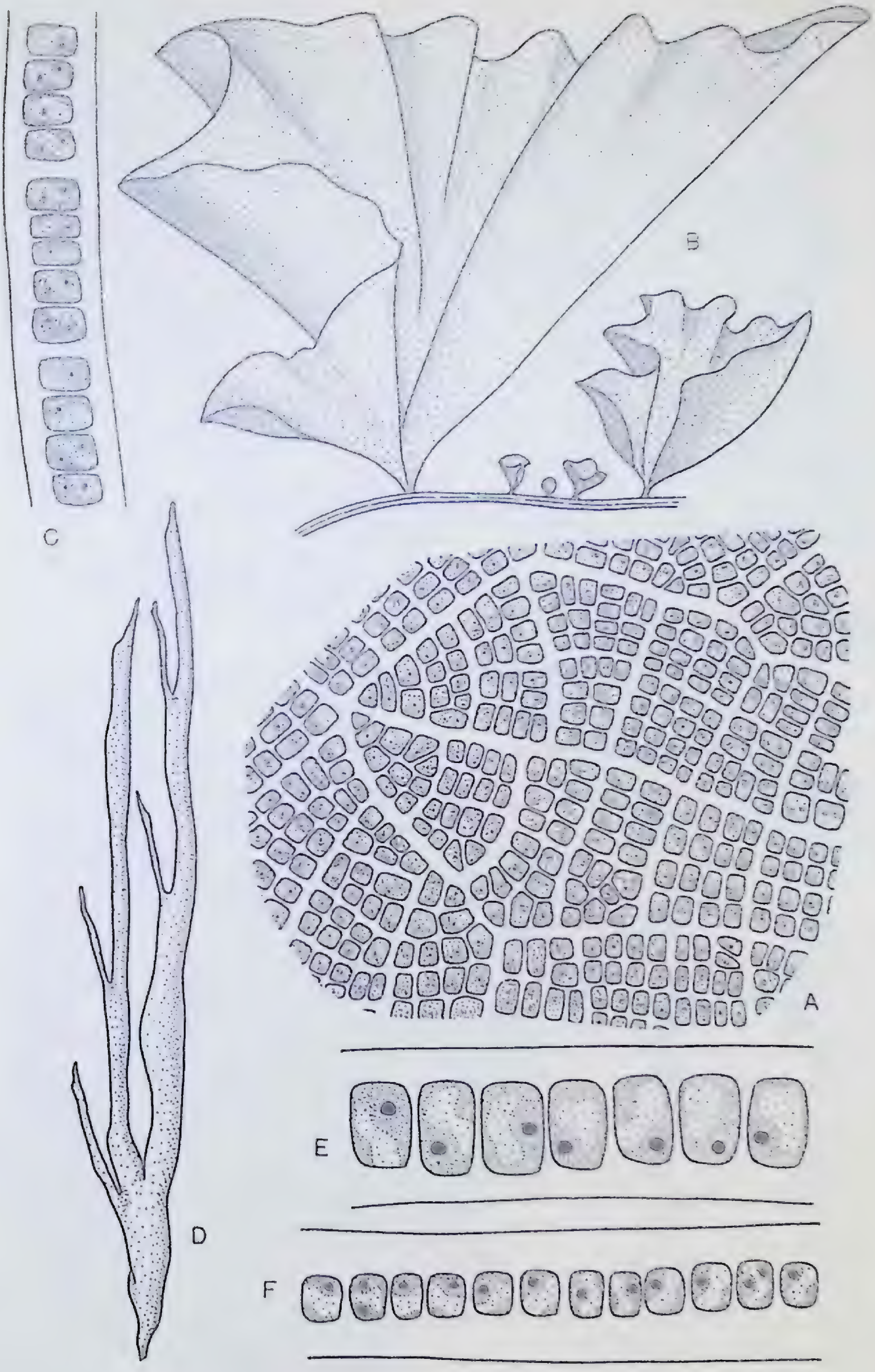

Plate 19

Monostroma fractum Jao

A. Surface view of thallus, X 1080.

Monostroma arcticum Wittrock

B. Surface view of thallus, X 720.

Monostroma fuscum var. *splendens* (Ruprecht) Rosenvinge

C. Section of thallus, X 1080.

Monostroma fuscum (Postels and Ruprecht) Wittrock var. *fuscum*

D. Section of thallus, X 1080.

Monostroma fuscum var. *blyttii* (Areschoug) Collins

E. Habit, X 0.5.

PLATE 19

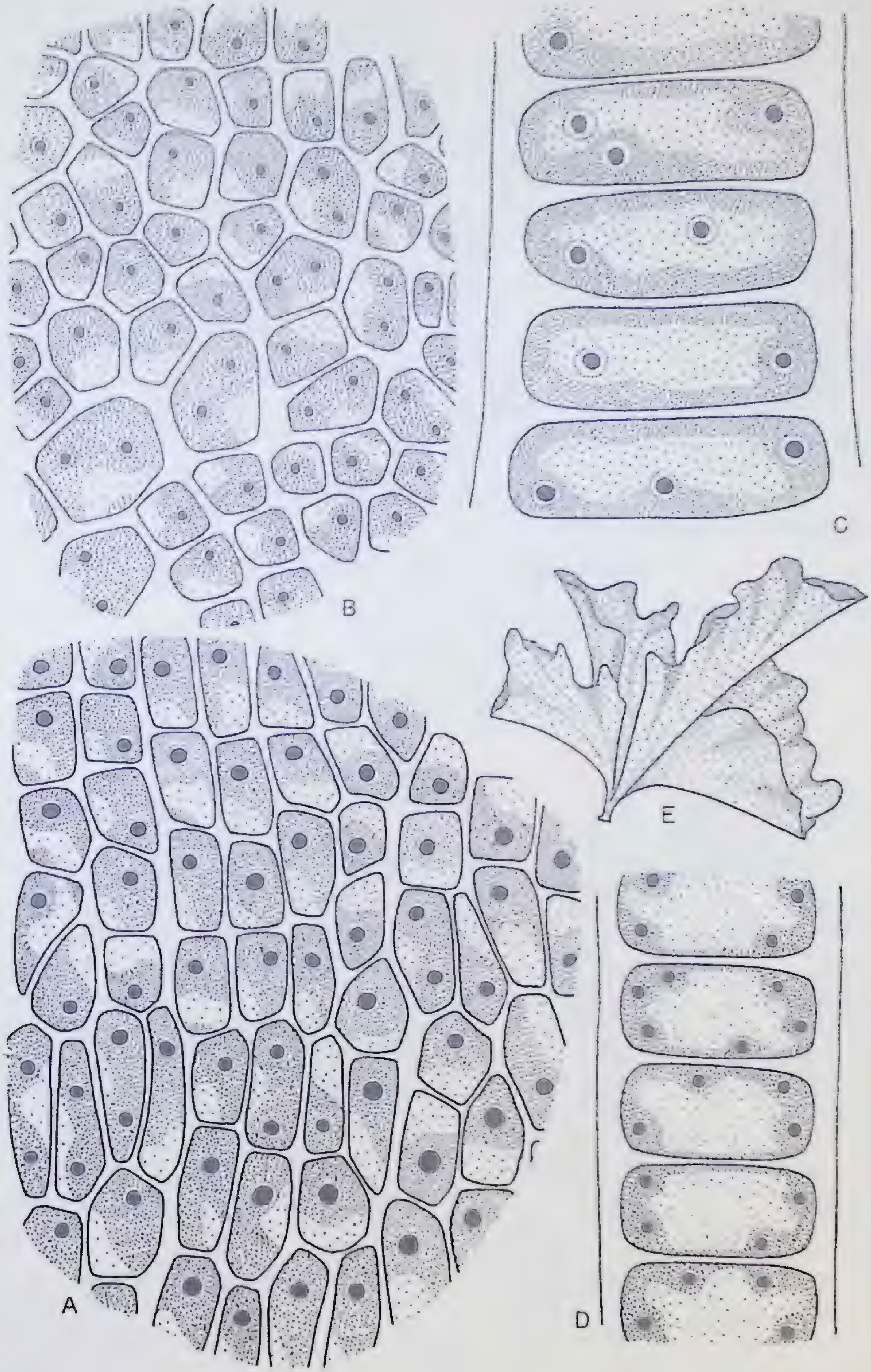

PLATE 20

Monostroma fuscum (Postels and Ruprecht) Wittrock var. *fuscum*

A. Habit, X 0.5.

Monostroma fuscum var. *splendens* (Ruprecht) Rosenvinge

B. Surface view of thallus, X 1080.

Monostroma oxyspermum (Kützing) Doty

C. Surface view of thallus, X 1080.

PLATE 20

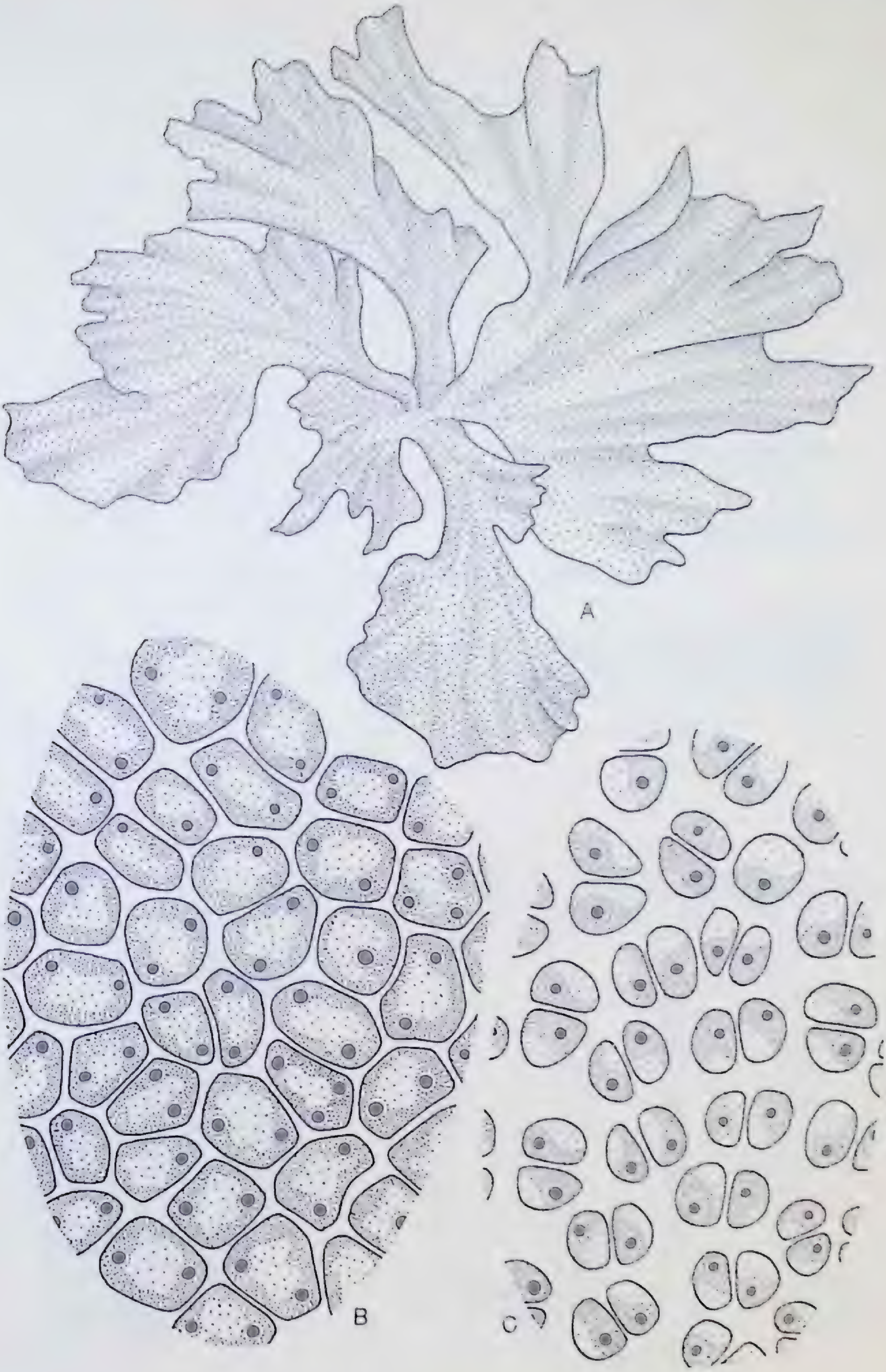

PLATE 21

Monostroma fuscum var. *blyttii* (Areschoug) Collins

A. Section of thallus, X 1080.

Monostroma oxyspermum (Kützing) Doty

B. Section of thallus, X 1080.

Blidingia minima (Nägeli) Kylin var. *minima*

C. Habit, X 5.
D. Surface view of thallus, X 1080.
E. Transverse section of a portion of the thallus, X 1080.

PLATE 21

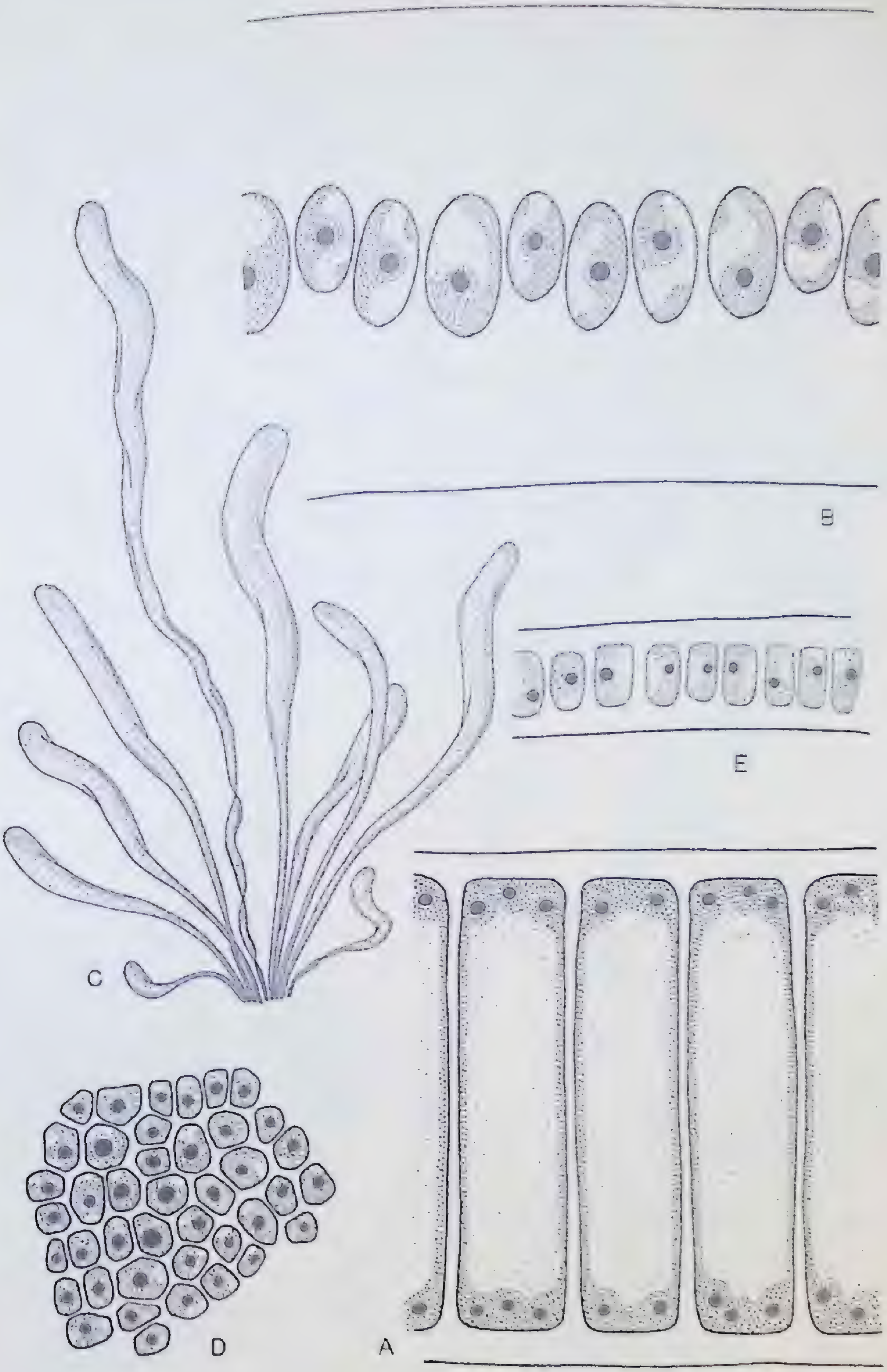

PLATE 22

Blidingia minima var. *subsalsa* (Kjellman) Scagel

A. Habit of tubular thallus showing branches, X 25.
B. View of a portion of the thallus showing branches, X 75.
C. Surface view of thallus in vicinity of a young branch, X 540.
D. Surface view of thallus, X 1080.

Enteromorpha clathrata (Roth) Greville

E. Habit, X 0.5.
F. Transverse section of a portion of the thallus, X 720.

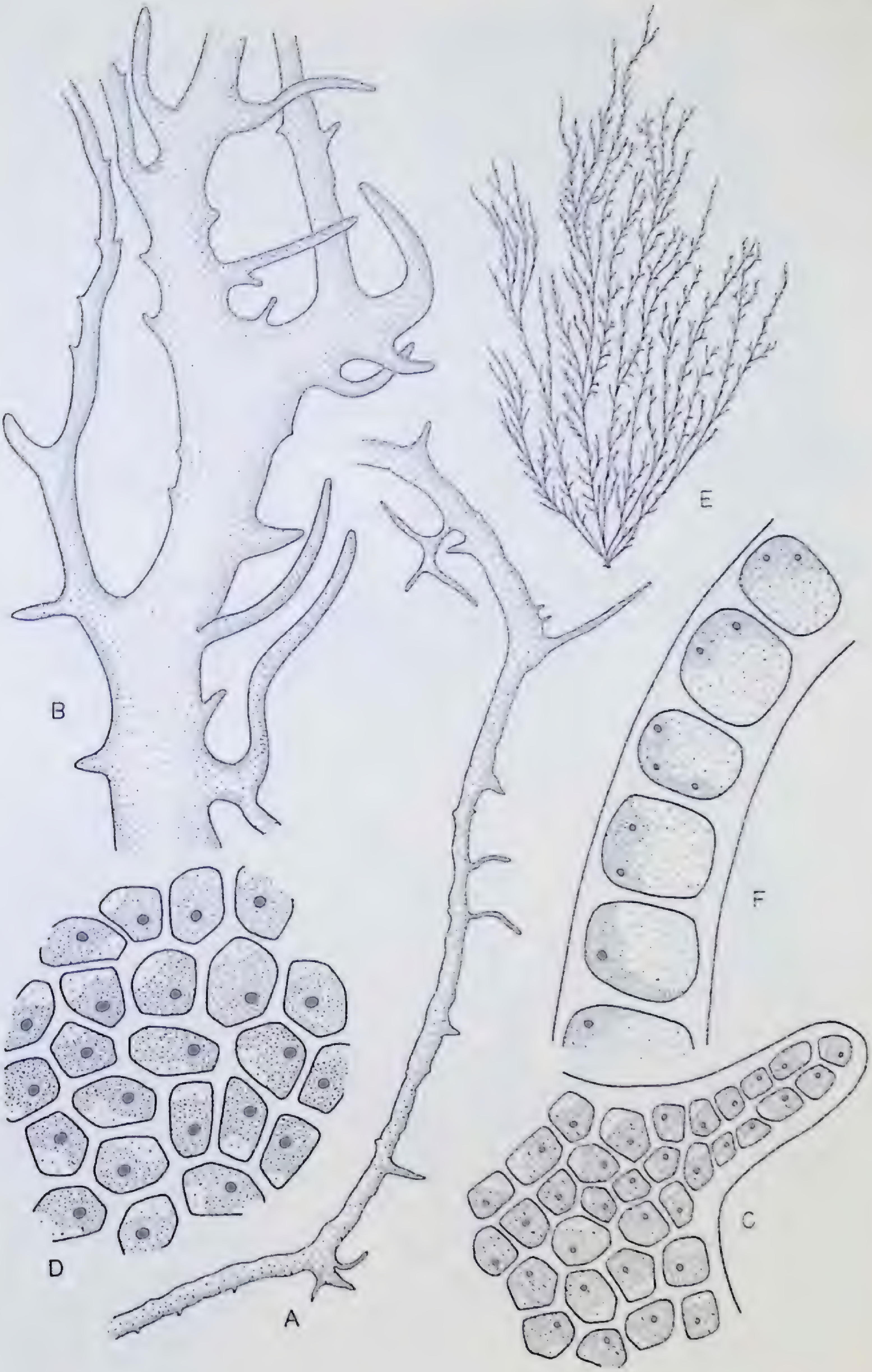
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PLATE 23

Enteromorpha clathrata (Roth) Greville

A. Surface view of thallus, X 375.
B. Surface view of a young branch apex, X 720.

Enteromorpha compressa (Linnaeus) Greville

C. Habit, X 0.5.
D. Transverse section of a portion of the thallus, X 720.
E. Surface view of a portion of the thallus in mature region, X 720.
F. Surface view of a portion of the thallus in a young branch, X 720.

PLATE 23

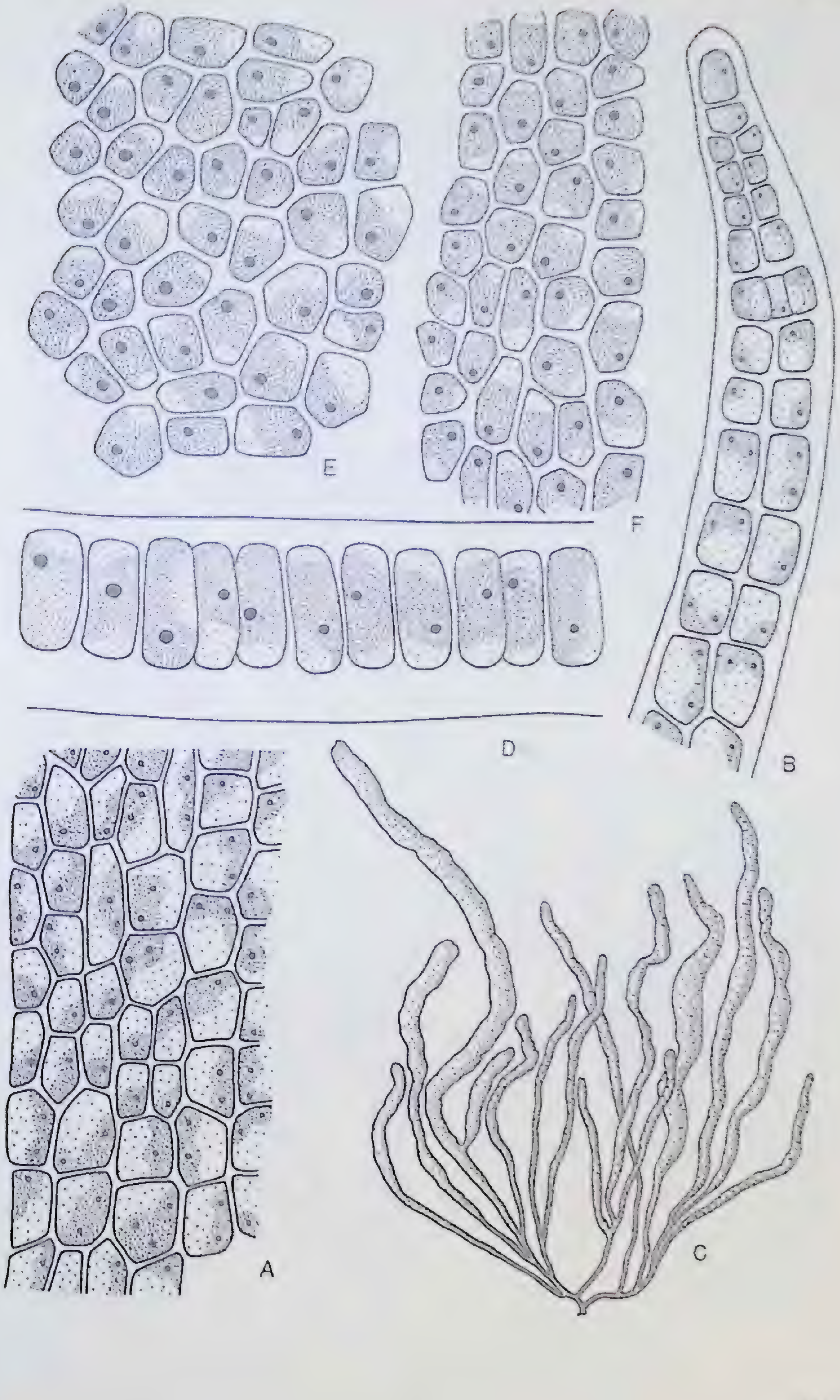

PLATE 24

Enteromorpha linza (Linnaeus) J. Agardh

A. Habit, X 0.5.
B. Surface view of cells in the stipitate, tubular portion of the thallus, X 500.
C. Surface view of cells near the apex in the flattened portion of the thallus, X 1080.
D. Transverse section of the margin near the apex of the thallus, X 375.
E. Transverse section of the thallus near the apex in the distromatic portion of the plant, X 720.
F. Transverse section of a portion of the thallus in the stipitate tubular region showing cells closer to outer than inner surface, X 1080.

PLATE 24

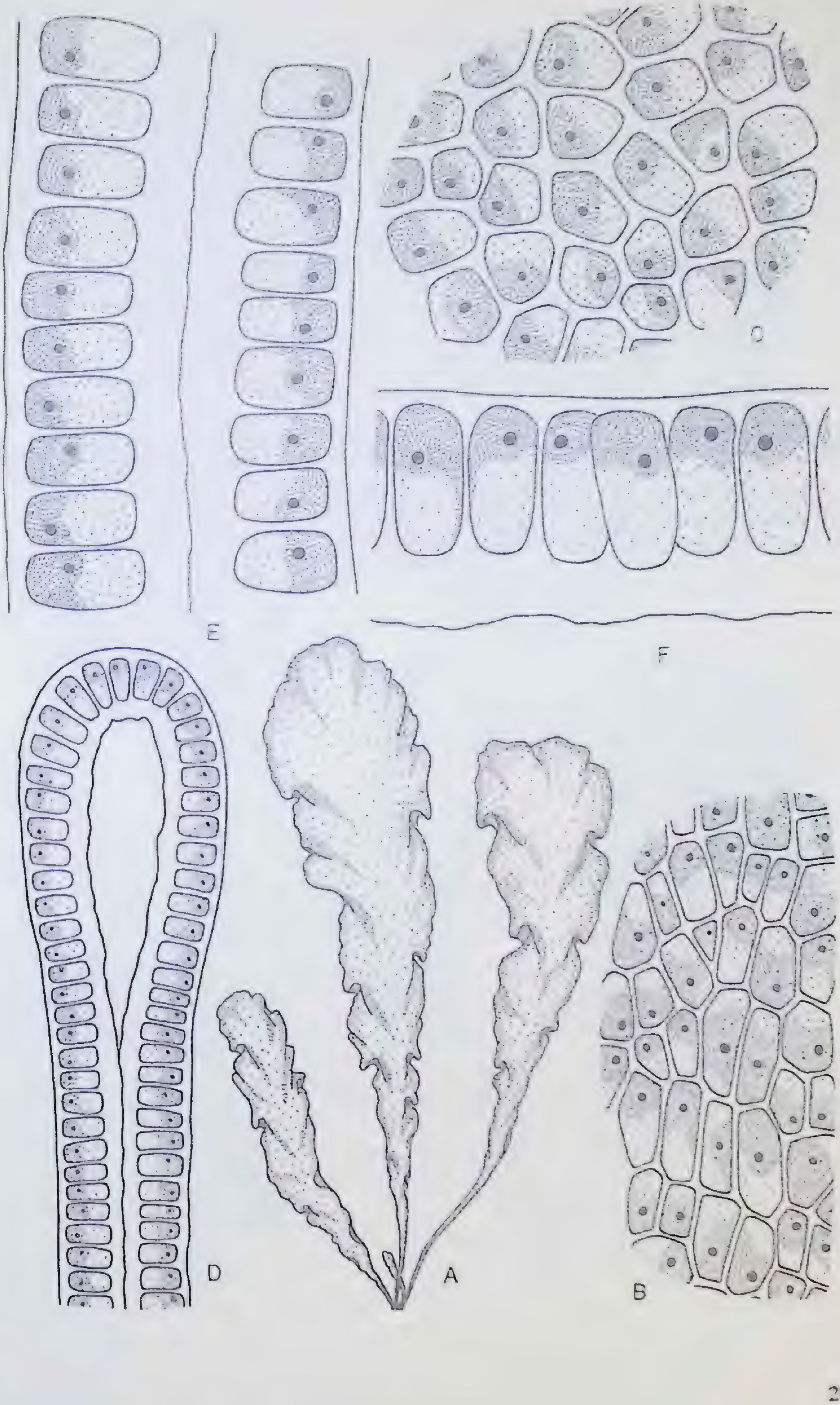

PLATE 25

Enteromorpha crinita (Roth) J. Agardh

A. Habit, X 40.
B. Surface view of a portion of the thallus showing uniseriate and biseriate branches, X 375.
C. Surface view of a portion of the thallus showing branches, X 720.
D. Surface view of a portion of the thallus, X 720.
E. Transverse section of a portion of the thallus, X 720.

PLATE 25

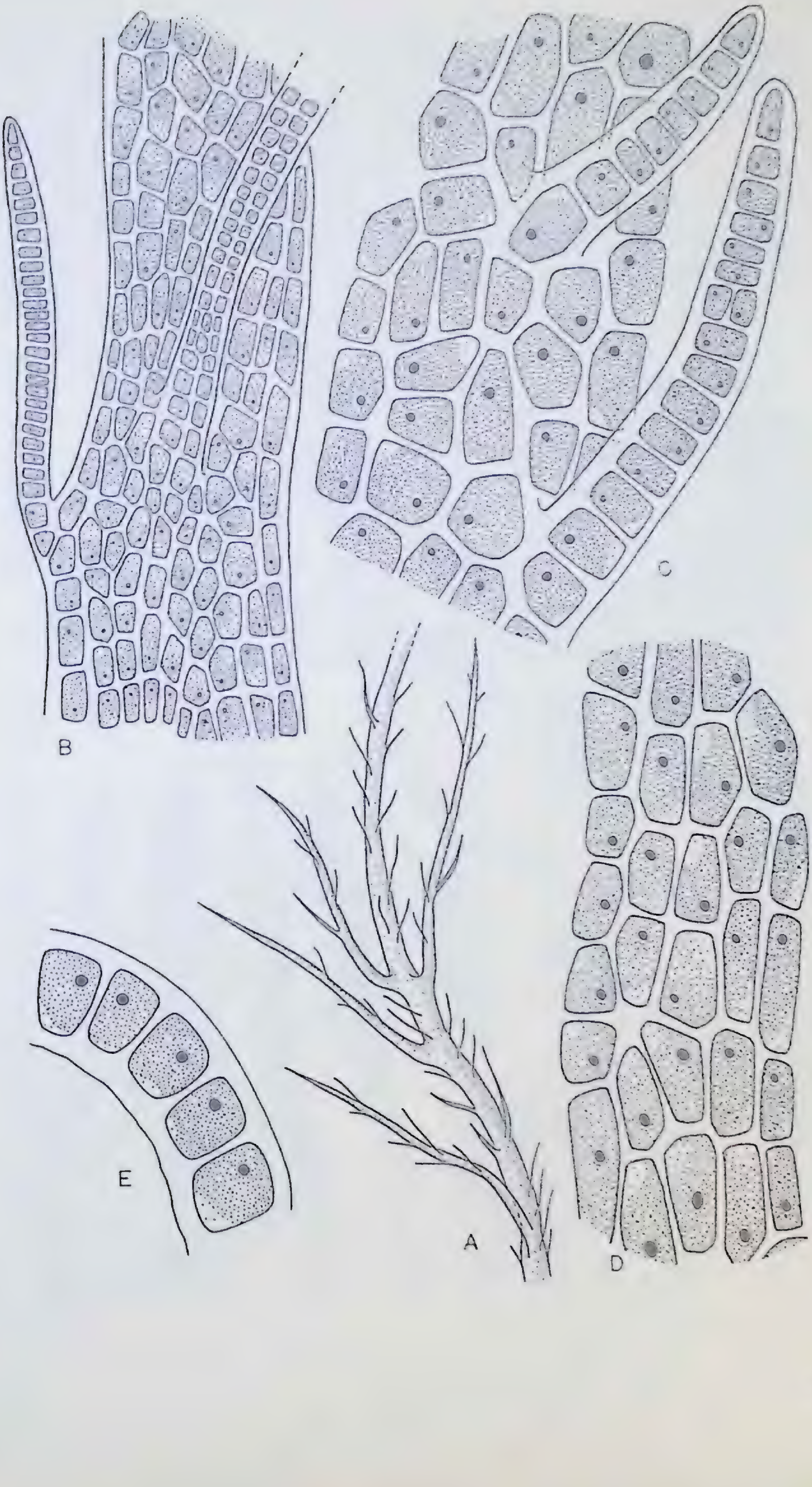

PLATE 26

Enteromorpha intestinalis (Linnaeus) Link var. *intestinalis*

A. Habit, X 1.
B. Transverse section of a portion of the thallus in the apical region, X 1080.
C. Transverse section of a portion of the thallus near the base, X 500.
D. Surface view of a portion of the thallus in the apical region, X 1080.
E. Surface view of a portion of the thallus near the base, X 1080.
F–K. Stages in germination of zygote, X 800.
L, M. Uniseriate filamentous germlings with rhizoidal base; L, X 800, M, X 300.
N. Later stage in development of filamentous germling, X 300.
O. Apical region of a young plant, X 300
P. Surface view of a portion of a young plant, X 350.
Q. Cross-sectional view of young plant in hollow portion near the base, X 350.

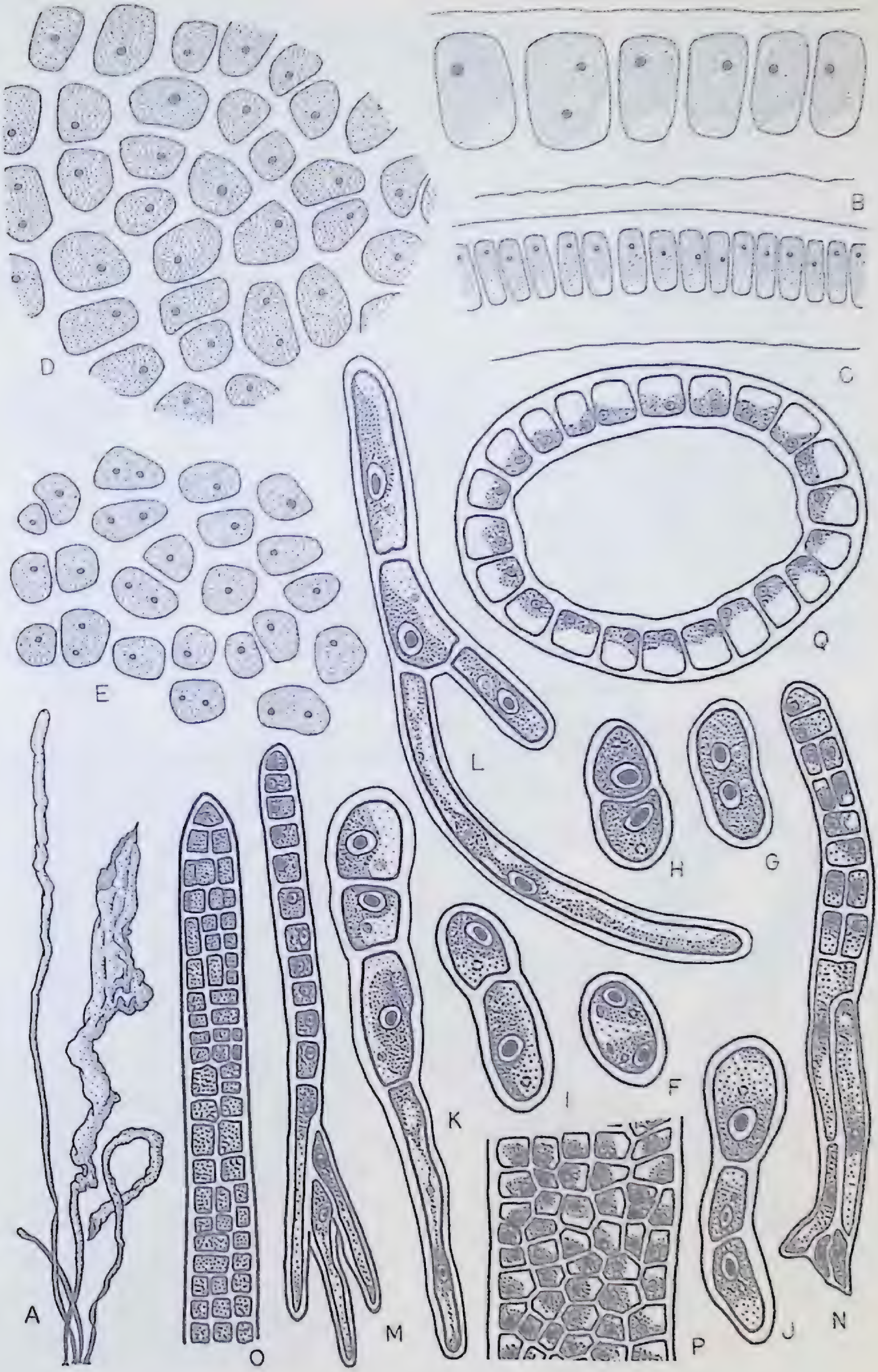
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PLATE 27

Enteromorpha intestinalis (Linnaeus) Link var. *intestinalis*

A. Empty and mature gametangia, X 650.
B. Free-swimming biflagellate gametes, X 800.
C. Planozygote, X 800.
D. Quadriflagellate zoospore, X 800.
E. Uniseriate filamentous germling, X 300.

Enteromorpha tubulosa Kützing

F. Transverse section through a portion of the thallus, X 1080.
G. Surface view of a portion of the thallus, X 720.

Enteromorpha marginata J. Agardh

H. Transverse section through a portion of the thallus, X 1080.
I. Surface view of a portion of the thallus showing base of a branch, X 1080.

Enteromorpha torta (Mertens) Reinbold

J. Surface view of a portion of the thallus showing a young branch, X 720.

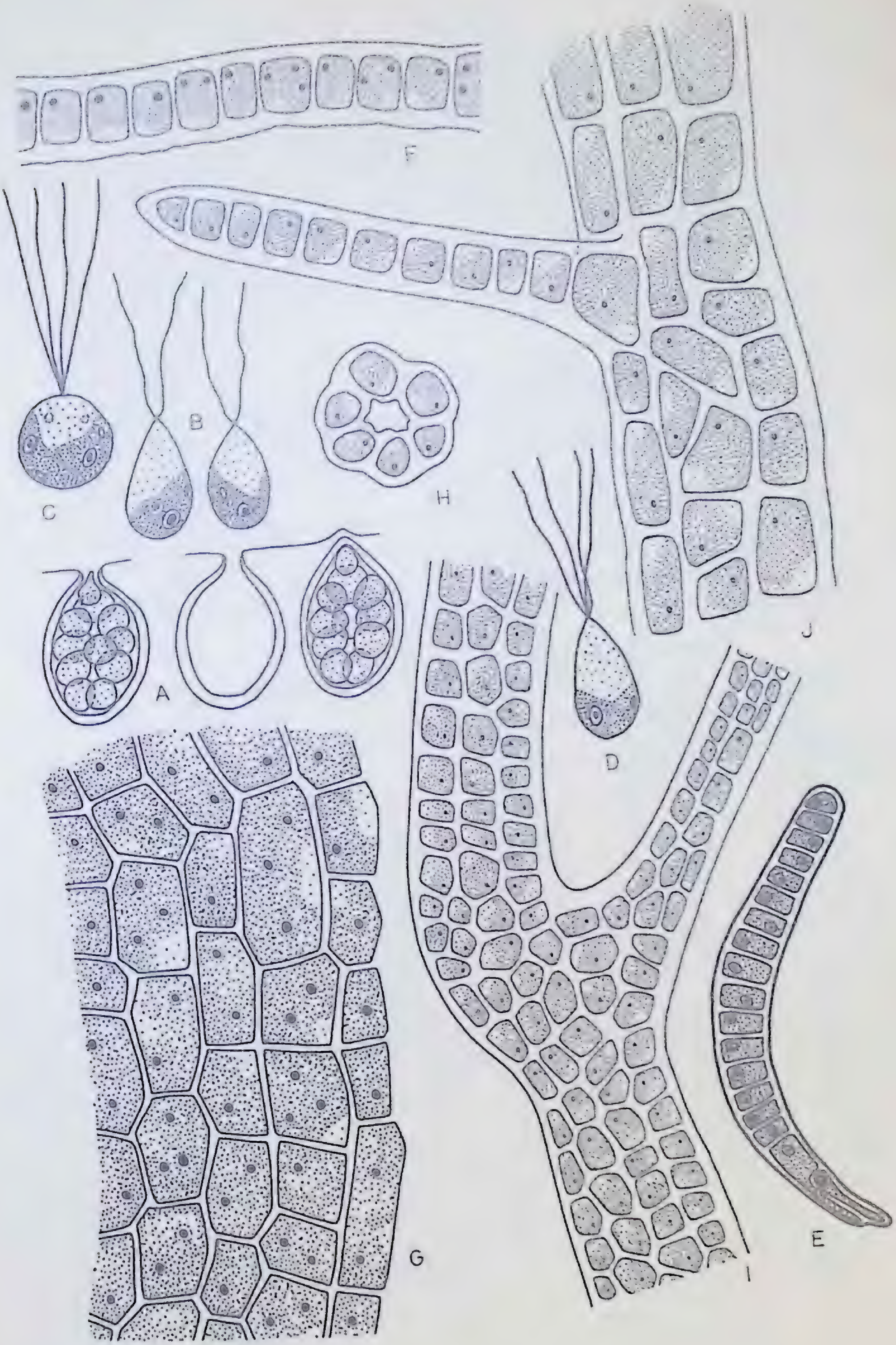
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PLATE 28

Enteromorpha torta (Mertens) Reinbold

A. Surface view of the thallus, X 1080.
B. Transverse section of the thallus, X 1080.

Enteromorpha intestinalis var. *clavata* J. Agardh

C. Habit, X 0.25.

Enteromorpha intestinalis var. *cylindracea* J. Agardh

D. Habit, X 0.25.

Enteromorpha prolifera (Müller) J. Agardh var. *prolifera*

E. Habit, X 0.25.
F. Transverse section of a portion of the thallus showing a young proliferous branch, X 500.
G. Surface view of the thallus, X 1080.

PLATE 28

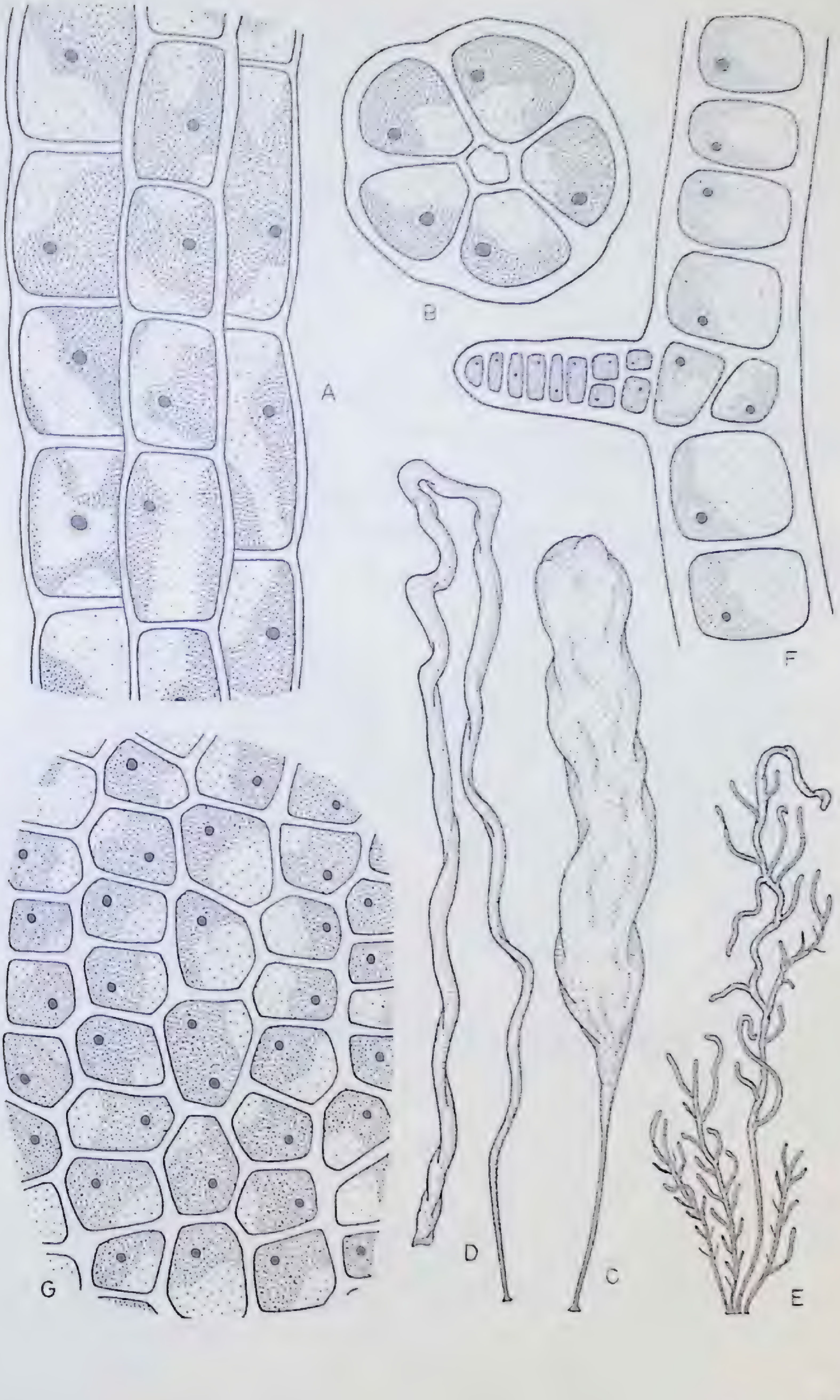

PLATE 29

Ulva expansa (Setchell) Setchell and Gardner

A. Transverse section of a portion of the thallus, X 1080.
B. Surface view of the thallus, X 1080.

Ulva fenestrata Postels and Ruprecht

C. Transverse section of a portion of the thallus, X 1080.
D. Surface view of the thallus, X 1080.
E. Habit view of a portion of the thallus, X 0.5.

PLATE 29

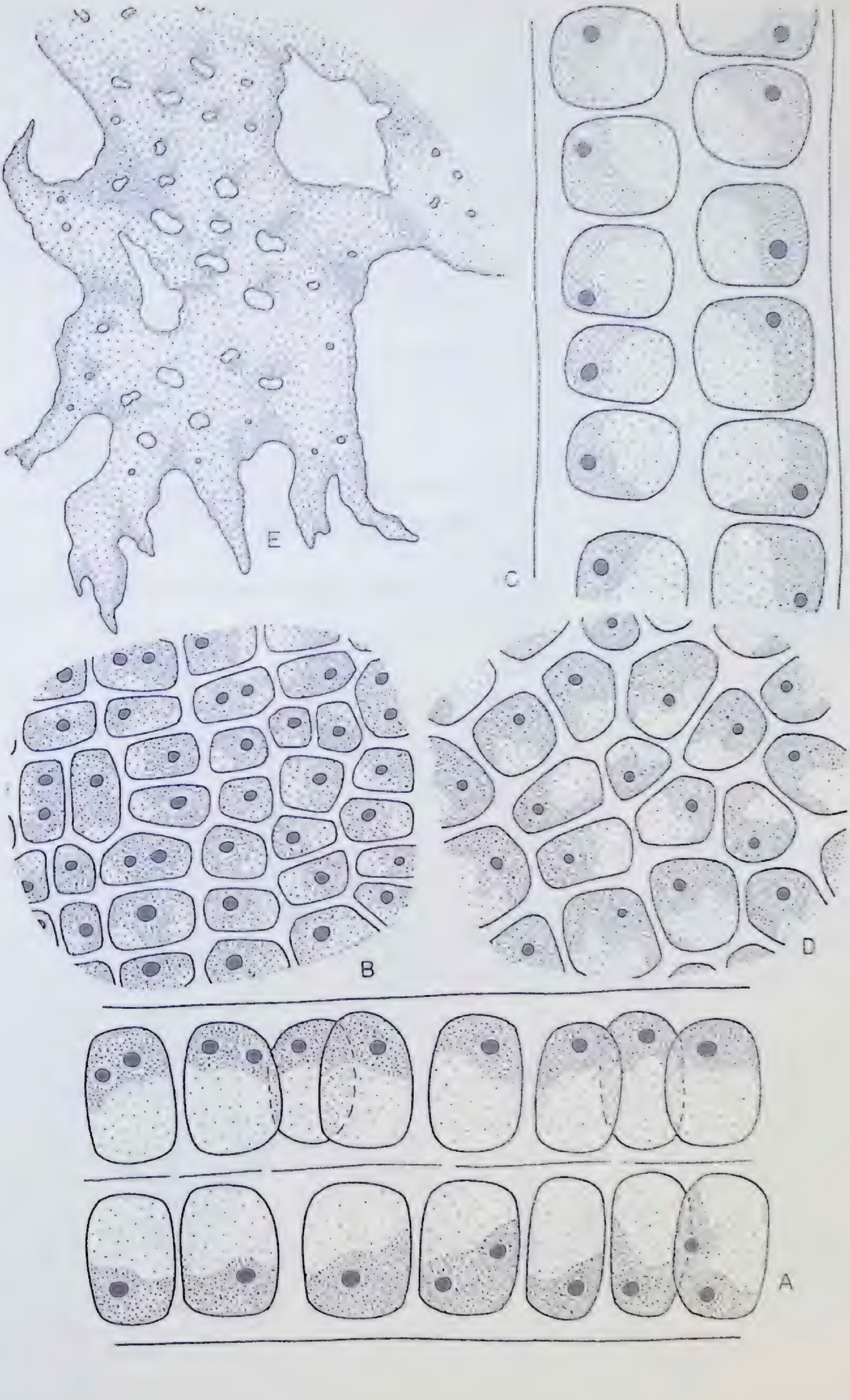

PLATE 30

Ulva rigida C. Agardh

A. Habit, X 0.5.
B. Surface view of the thallus, X 1080.
C. Transverse section of a portion of the thallus, X 1080.

Ulva vexata Setchell and Gardner

D. Habit, X 2.
E. Transverse section of a portion of the thallus, showing filaments of endophytic fungus, X 1080.
F. Surface view of the thallus, X 1080.

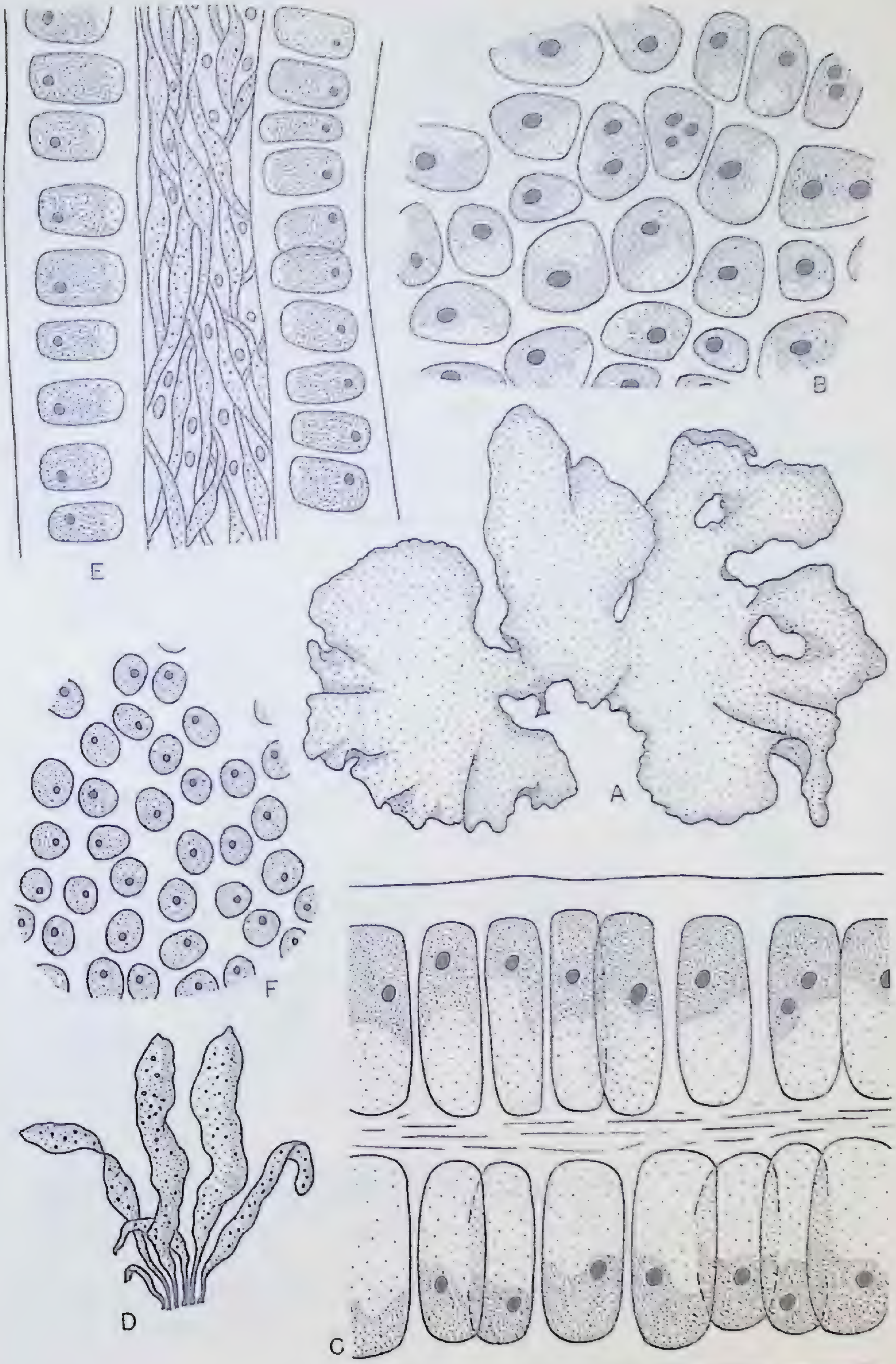
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PLATE 31

Ulva rigida C. Agardh

A. Zoospore, X 1080.
B–H. Stages in germination of zoospore and development of juvenile thallus, X 1080.

Ulva lactuca Linnaeus

I. Habit, X 0.5.
J. Surface view of a portion of the thallus, X 500.
K. Transverse section of a portion of the thallus, X 500.

PLATE 31

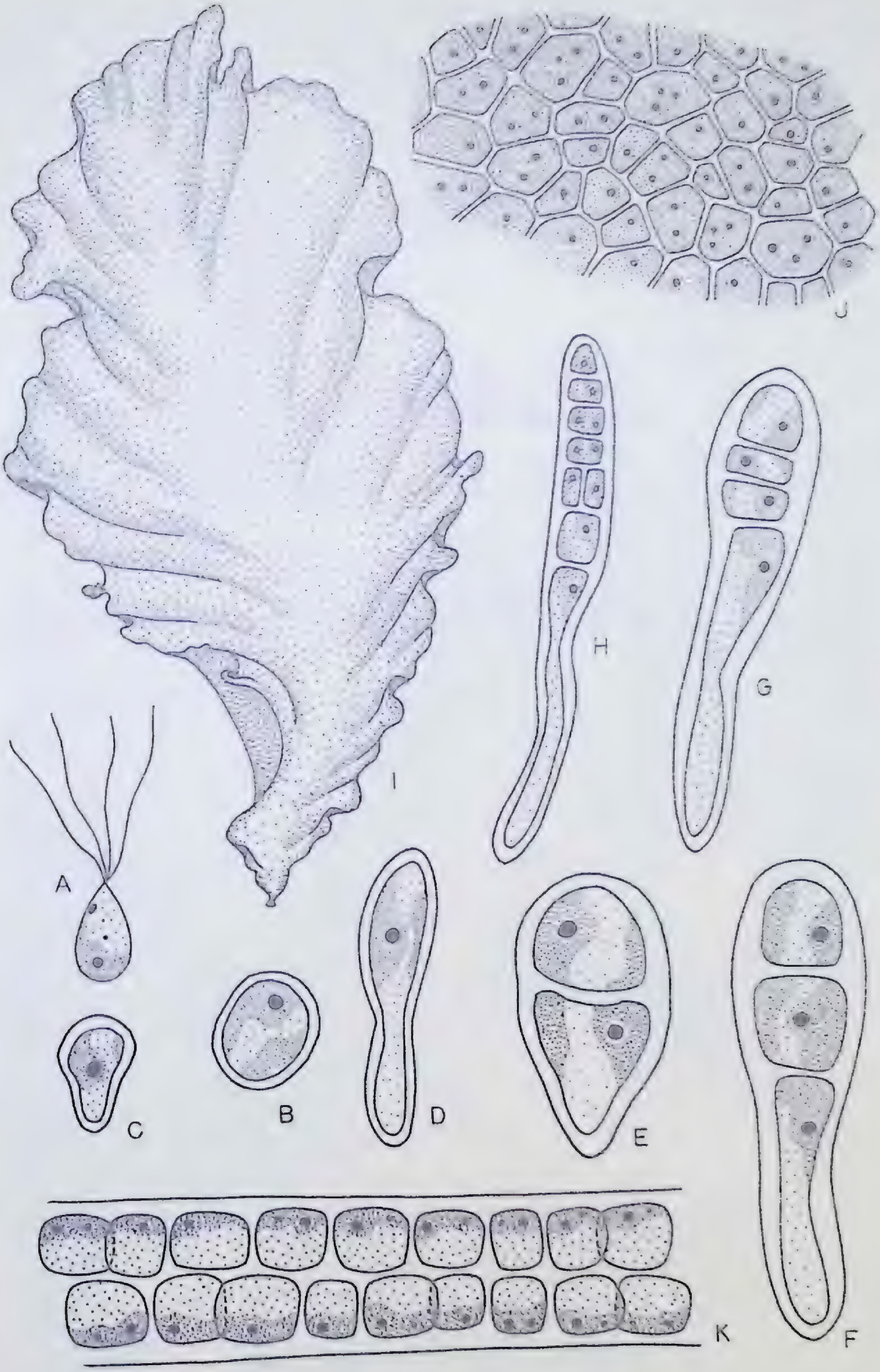

PLATE 32

Rhizoclonium riparium (Roth) Harvey

A–D. Various portions of filamentous thallus showing rhizoidal branches, X 375.
E. Portion of the filamentous thallus showing reticulate chloroplast, pyrenoids, and nuclei, X 720.

Lola lubrica (Setchell and Gardner) A. and G. Hamel

F. Portion of unbranched filamentous thallus, X 235.
G. Portion of the filamentous thallus showing reticulate chloroplast, pyrenoids, and nuclei, X 450.

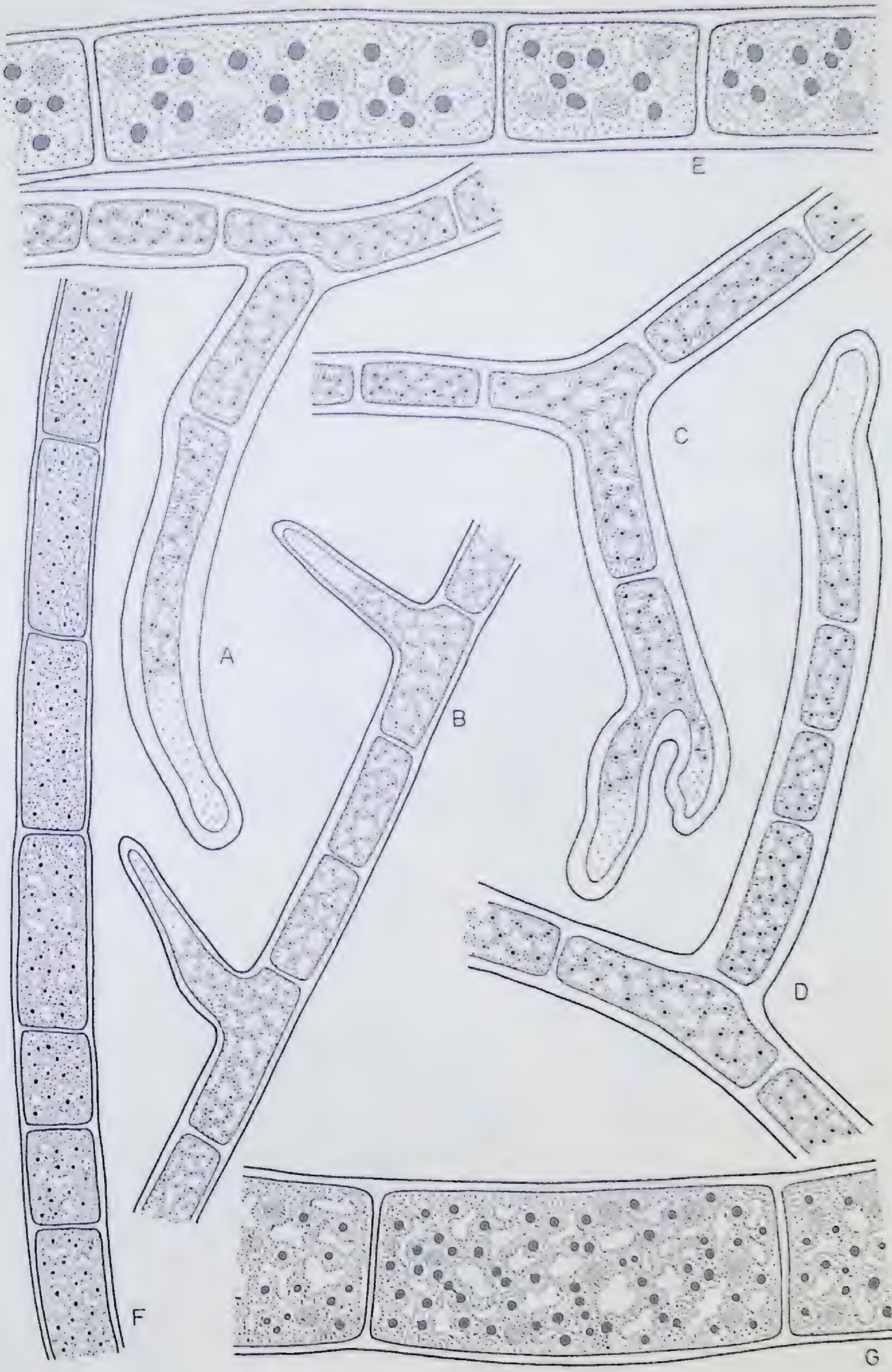
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PLATE 33

Rhizoclonium implexum (Dillwyn) Kützing

A, B. Vegetative filament showing multinucleate cells; A, X 720; B, X 1080.

Chaetomorpha recurva (Jao) nom. nov.

C. Habit, showing several filaments epiphytic on cells of *Acrochaetium*, X 110.
D. Distal portion of filament showing mucronate apical cell, X 1000.
E. Basal portion of filament showing discoid holdfast cell, X 1000.

Chaetomorpha cannabina (Areschoug) Kjellman

F, G. Portions of vegetative filaments, X 75.
H. Portion of cell showing detail of chloroplast with numerous pyrenoids, X 500.

Urospora vancouveriana (Tilden) Setchell and Gardner

I. View from the surface of a portion of a sporangium, showing stage in development of zoospores, each with a conspicuous pyrenoid, X 1080.

PLATE 33

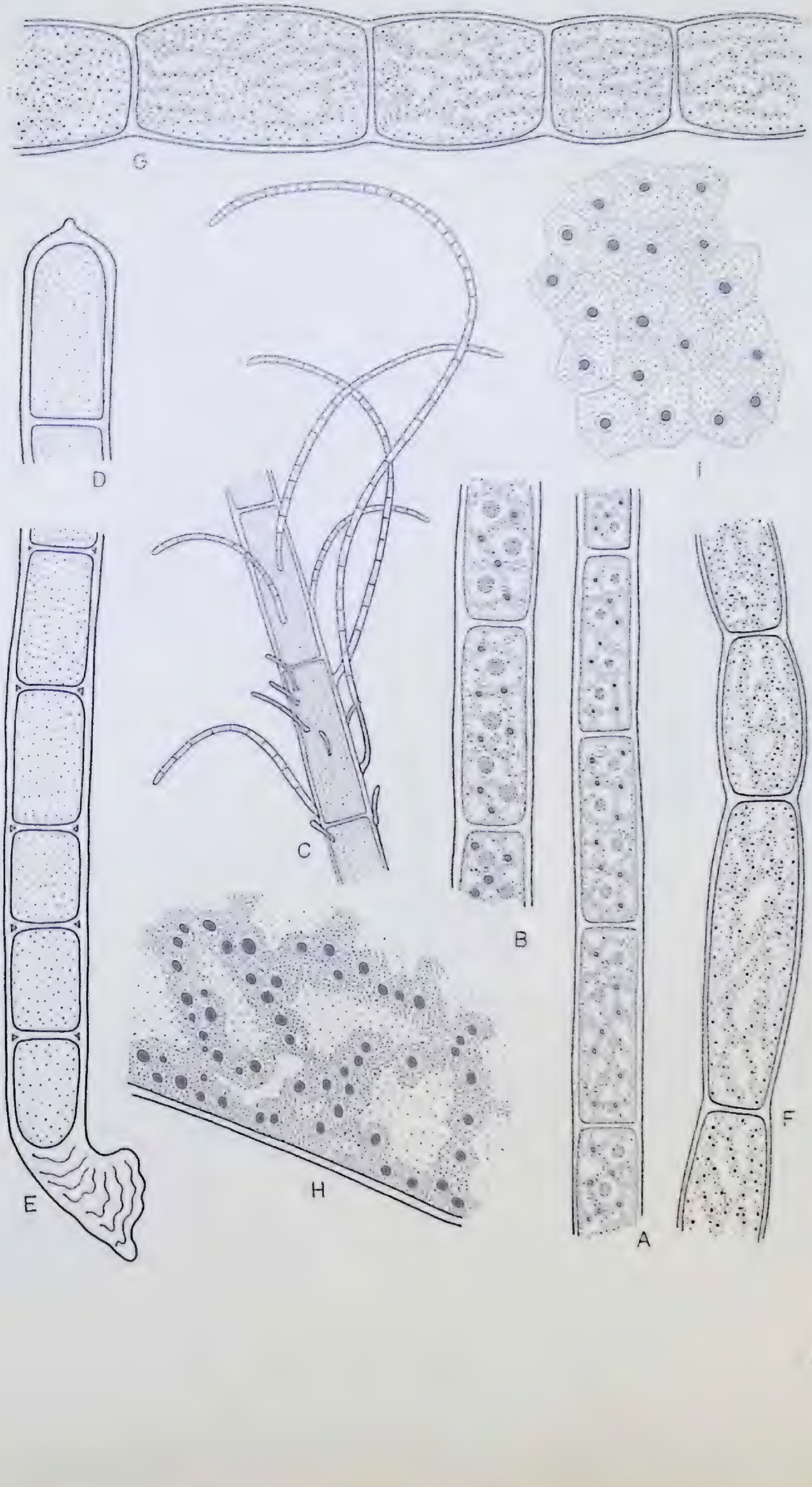

PLATE 34

Chaetomorpha californica Collins

A. Juvenile plant, X 375.
B. Basal part of filamentous thallus, showing discoid holdfast cell, X 375.
C. Portion of filament showing multinucleate cell, X 1080.

Urospora vancouveriana (Tilden) Setchell and Gardner

D. Habit of plant, X 4.
E. Portion of a filament in vegetative condition with inconspicuously perforate chloroplast, X 115.
F. Holdfast region of thallus showing intramatrical rhizoidal cells, X 500.

PLATE 34

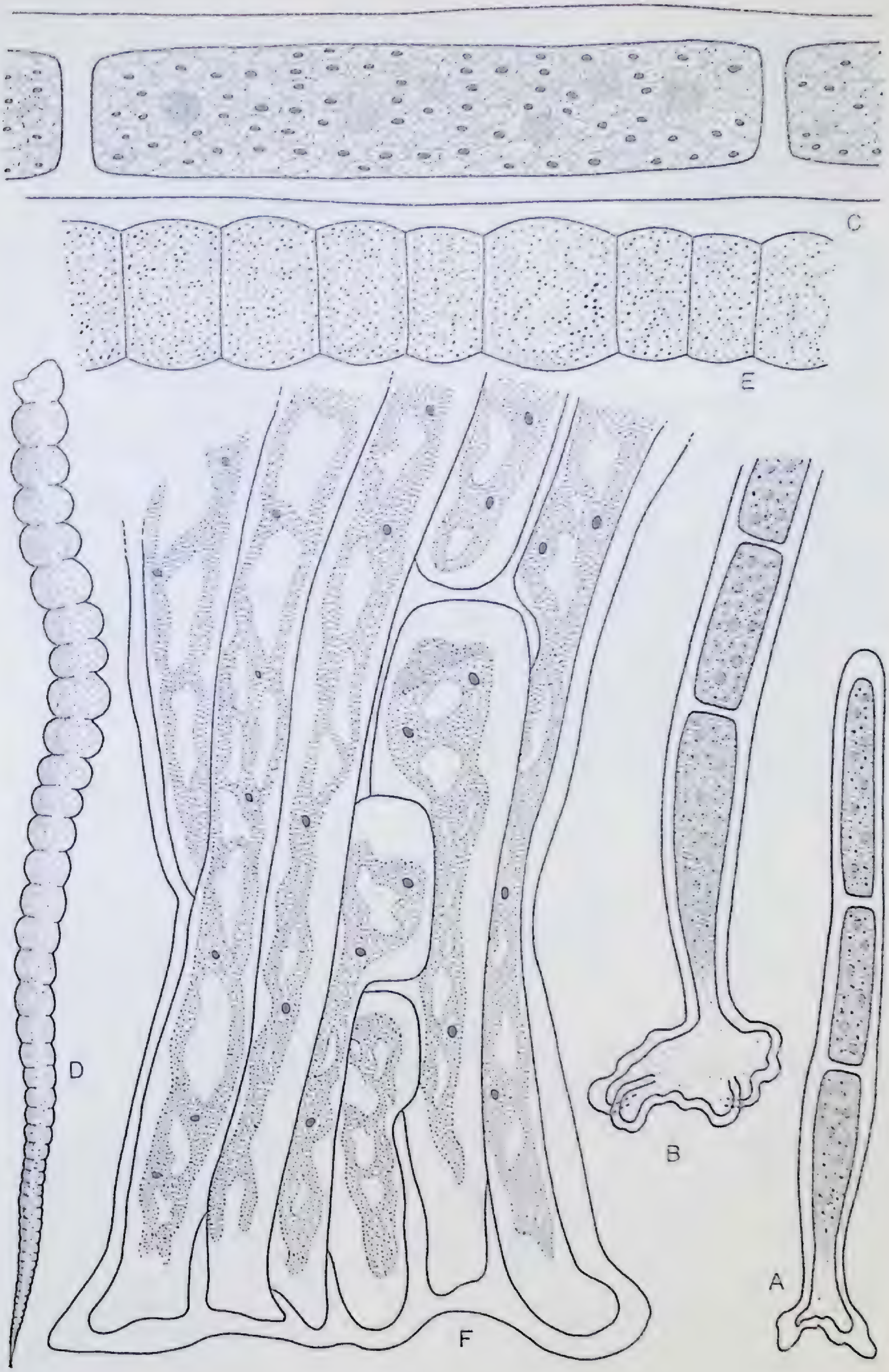

Plate 35

Urospora vancouveriana (Tilden) Setchell and Gardner

A. Vegetative portion of a mature filament showing shape of cells, X 30.
B. Fertile portion of the thallus showing shape of sporangia, X 30.
C. View of a portion of the surface of a young cell showing appearance of perforate chloroplast, X 1080.
D. View of a portion of the surface of a mature vegetative cell showing appearance of perforate chloroplast, X 1080.
E. Quadriflagellate zoospore with conspicuous pyrenoid, X 1080.
F. View of a portion of the basal region of the filament showing detail of part of the chloroplast in a rhizoidal cell, X 375.

Urospora wormskjoldii (Mertens) Rosenvinge

G, H. Fertile portions of filaments, X 75.

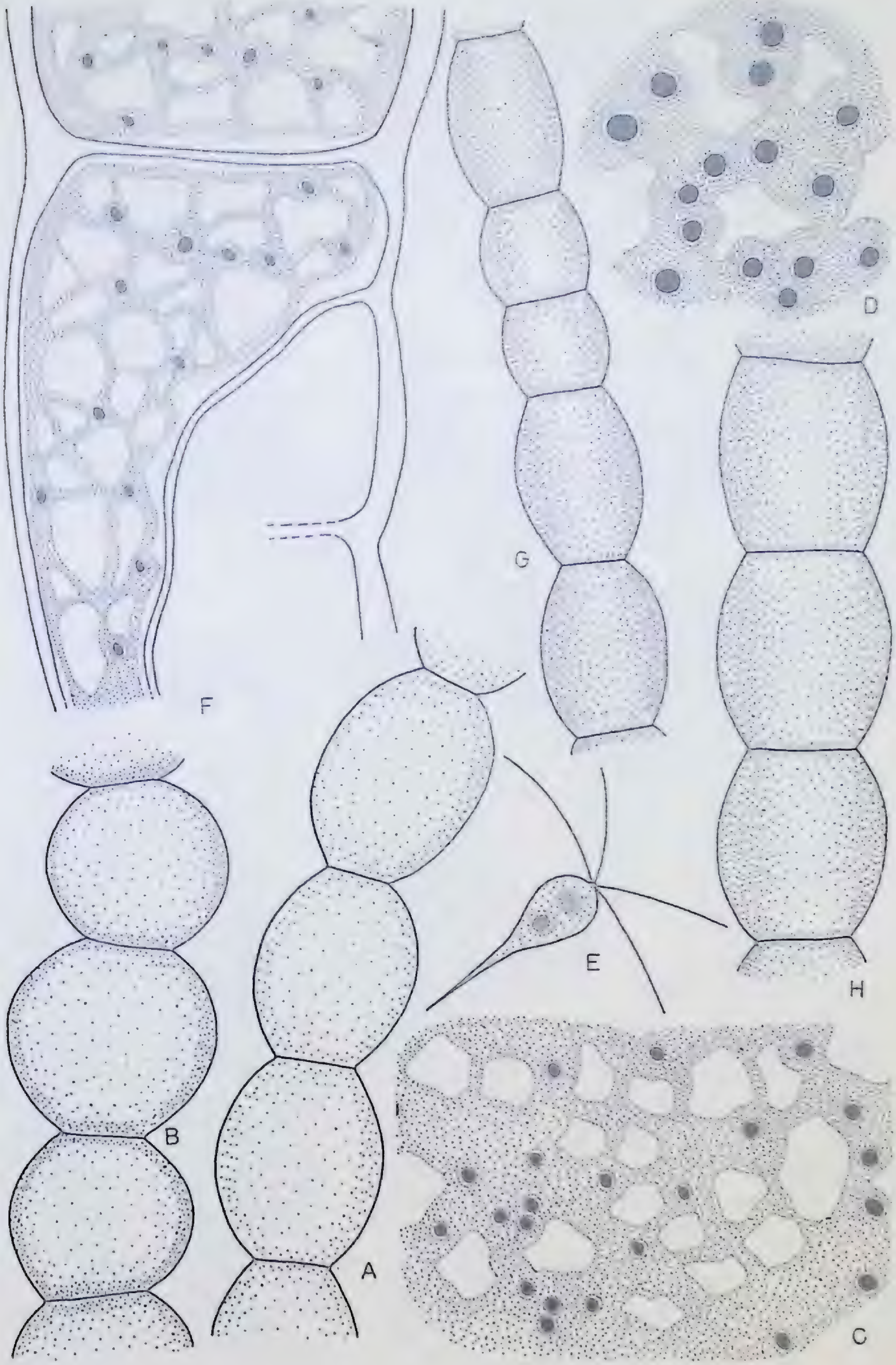
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PLATE 36

Urospora mirabilis Areschoug

A. Portion of a filament in the vegetative condition, X 375.
B. Basal portion of the filamentous thallus showing extramatrical rhizoidal cells, X 375.
C, D. Portions of filament in the fertile condition showing sporangia containing a large number of zoospores (D shows two empty sporangia), X 375.

Urospora wormskjoldii (Mertens) Rosenvinge

E. Vegetative portion of a mature filament showing shape of cell, numerous pyrenoids, and perforate chloroplast, X 375.
F. Basal portion of thallus showing holdfast of intramatrical rhizoidal cells, X 200.
G, H. Vegetative regions of younger portions of the thallus, X 375.
I. Fertile portion of the thallus showing swollen shape of cells and appearance of the mature sporangium, X 375.

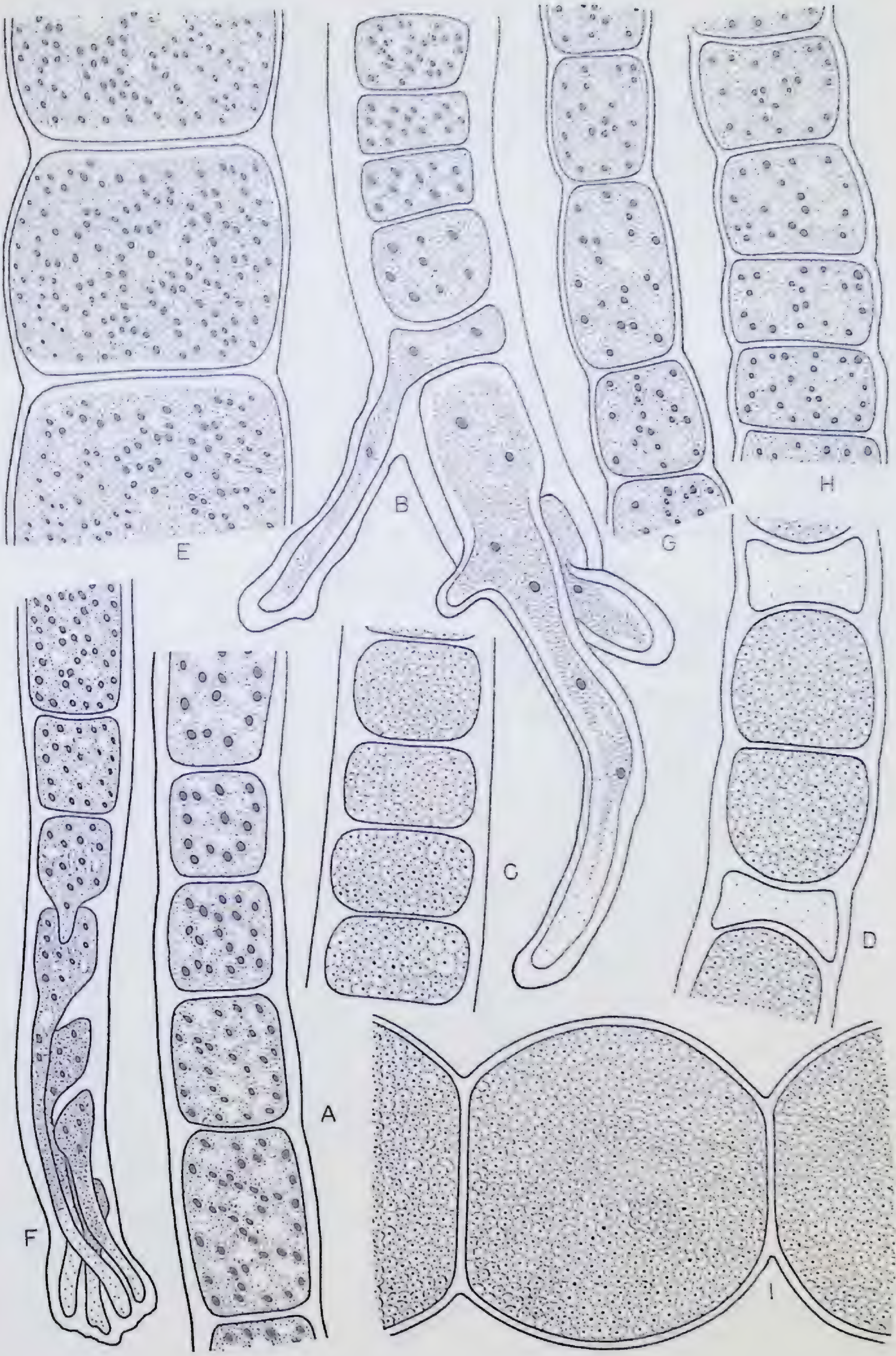
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PLATE 37

Spongomorpha arcta (Dillwyn) Kützing

A. Habit, X 1.
B. Basal portion of branched system showing several rhizoidal filaments and holdfast, X 75.
C. Apical portion of distal branch, X 115.
D. Portion of cell showing detail of chloroplast, X 1080.

Spongomorpha coalita (Ruprecht) Collins

E. Apical portion of lateral branch, X 115.
F. Gamete, X 1550.

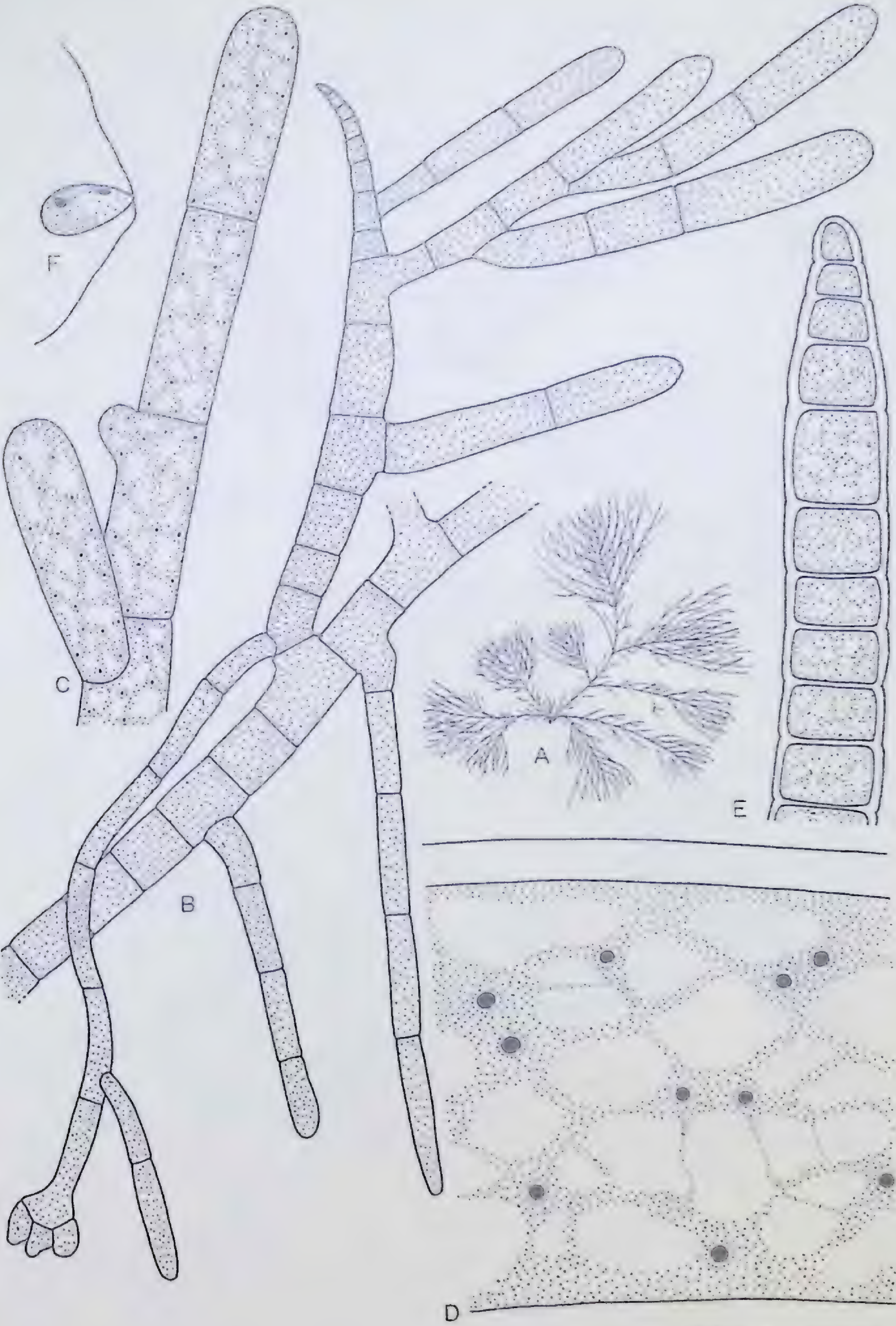
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PLATE 38

Spongomorpha arcta (Dillwyn) Kützing

A. Portion of apical region of branch system, X 32.

Spongomorpha coalita (Ruprecht) Collins

B. Portion of apical region of branch system, X 20.
C. Simple branchlet, X 32.
D. Compound branchlet, X 32.
E. Portion of filament showing detail of chloroplast, X 450.

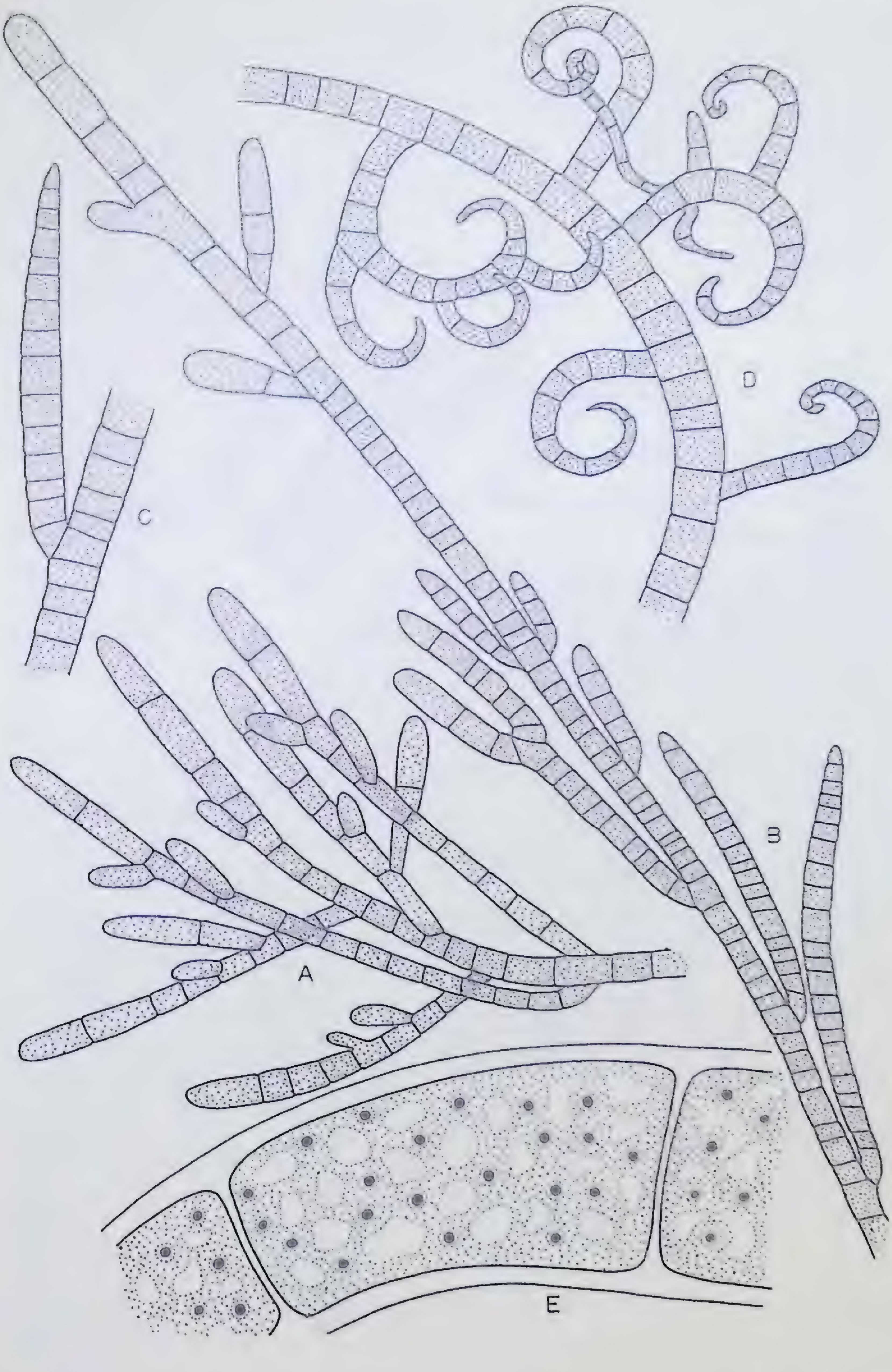
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PLATE 39

Spongomorpha coalita (Ruprecht) Collins

A. Habit, X 1.
B. Apical portion of distal branch, X 45.

Spongomorpha mertensii (Ruprecht) Setchell and Gardner

C. Simple branchlet, X 32.
D. Habit, X 1.
E. Portion of apical region of branch system, X 20.
F. Apical portion of distal branch, X 115.
G. Portion of cell showing detail of chloroplast, X 500.

PLATE 39

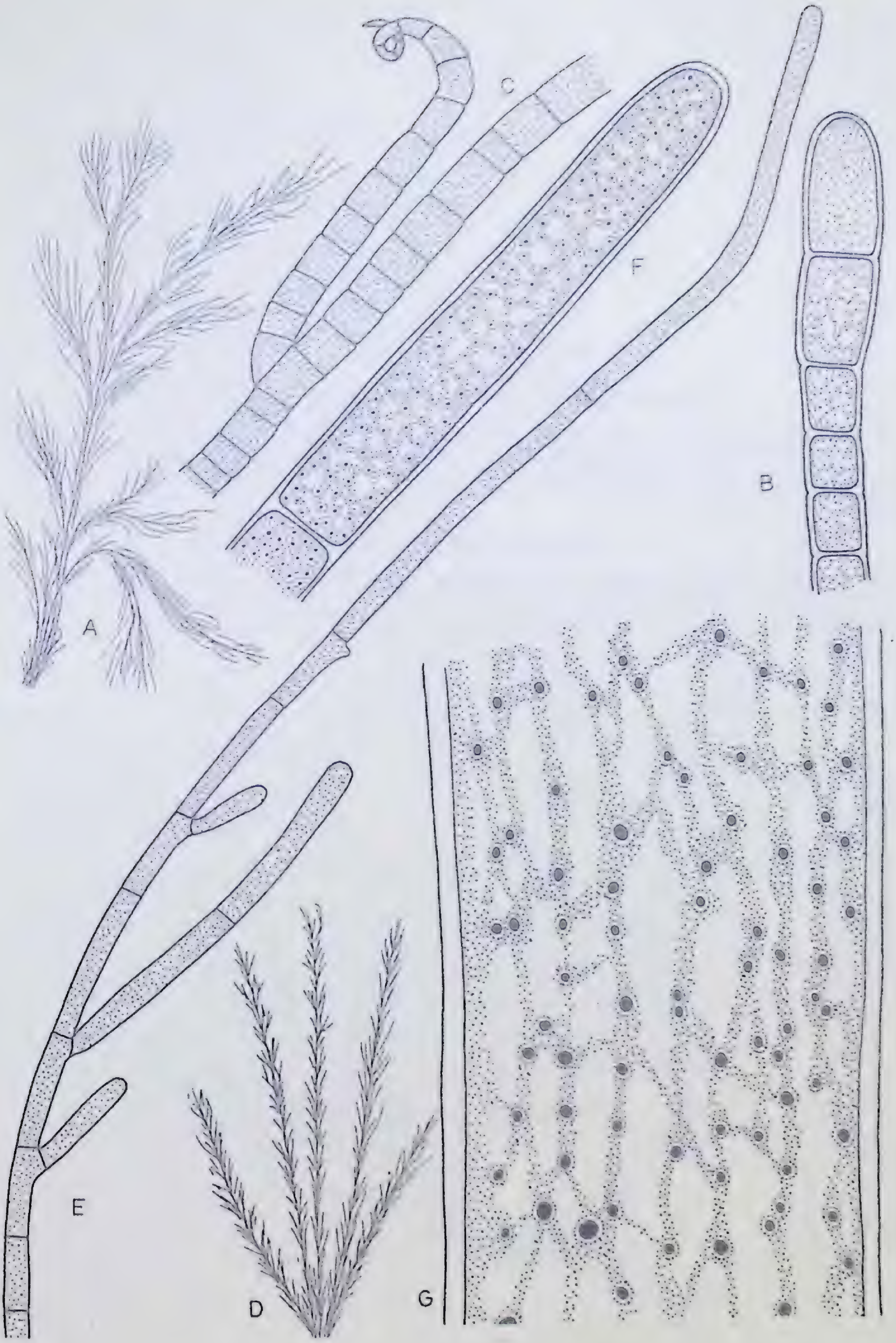

PLATE 40

Spongomorpha mertensii (Ruprecht) Setchell and Gardner

A. Portion of thallus in distal region showing origin of branches, X 20.
B. Portion of thallus in proximal region showing simple rhizoid, X 115.
C. Simple branchlet, X 115.
D. Compound branchlet, X 75.

Spongomorpha saxatilis (Ruprecht) Collins

E. Portion of thallus in distal region showing origin of branches, X 75.
F. Portion of lateral branch system, X 375.
G. Portion of filament showing detail of chloroplast, X 500.

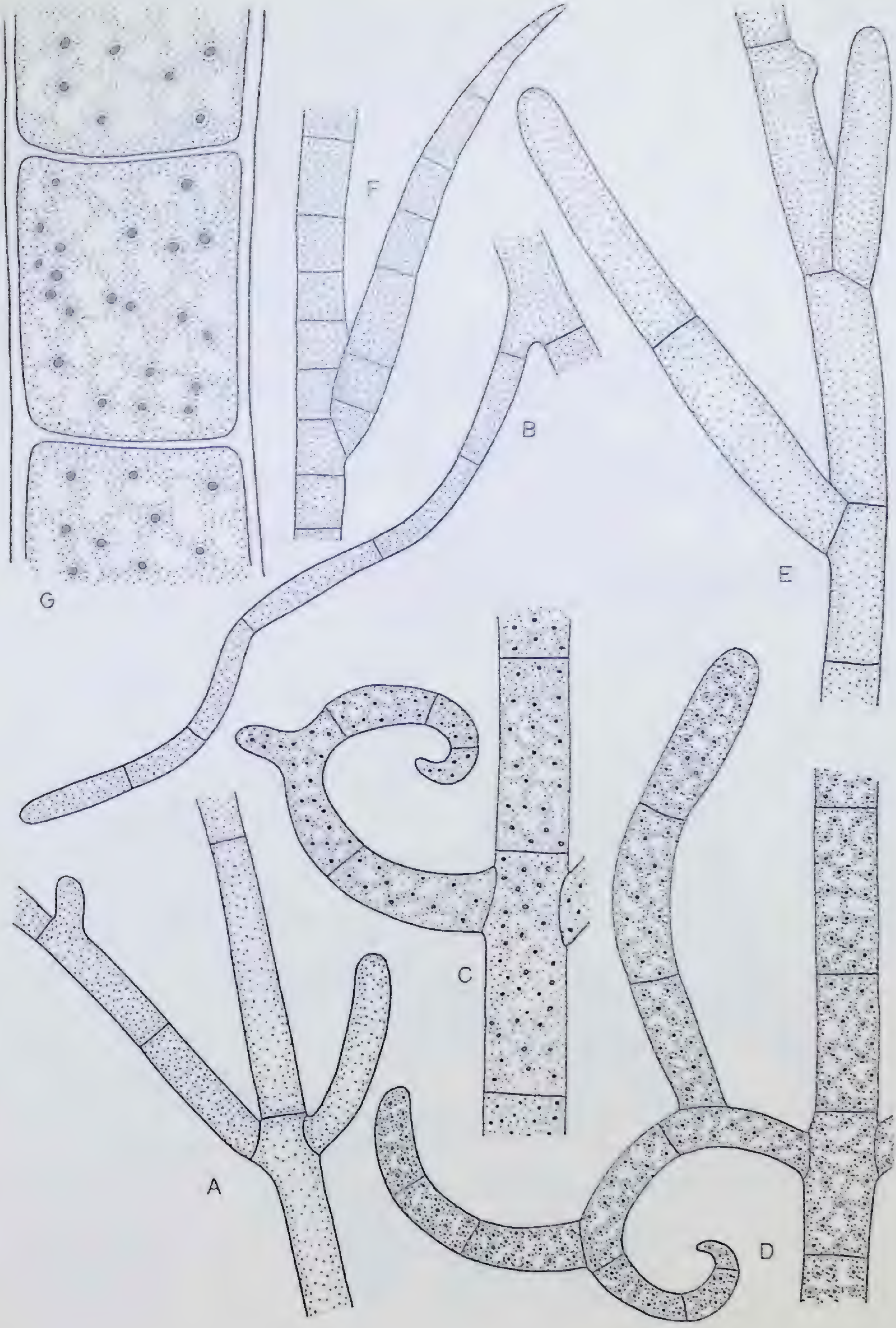
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PLATE 41

Spongomorpha saxatilis (Ruprecht) Collins

A. Habit, X 1.
B. Portion of apical region of branch system, X 32.
C. Portion of thallus in basal region showing branched rhizoids, X 115.
D. Apical region of lateral branch, X 375.

Spongomorpha spinescens Kützing

E. Portion of apical region of branch system, X 50.
F. Detail of rhizoidal filament showing non-septate holdfast, X 375.

PLATE 41

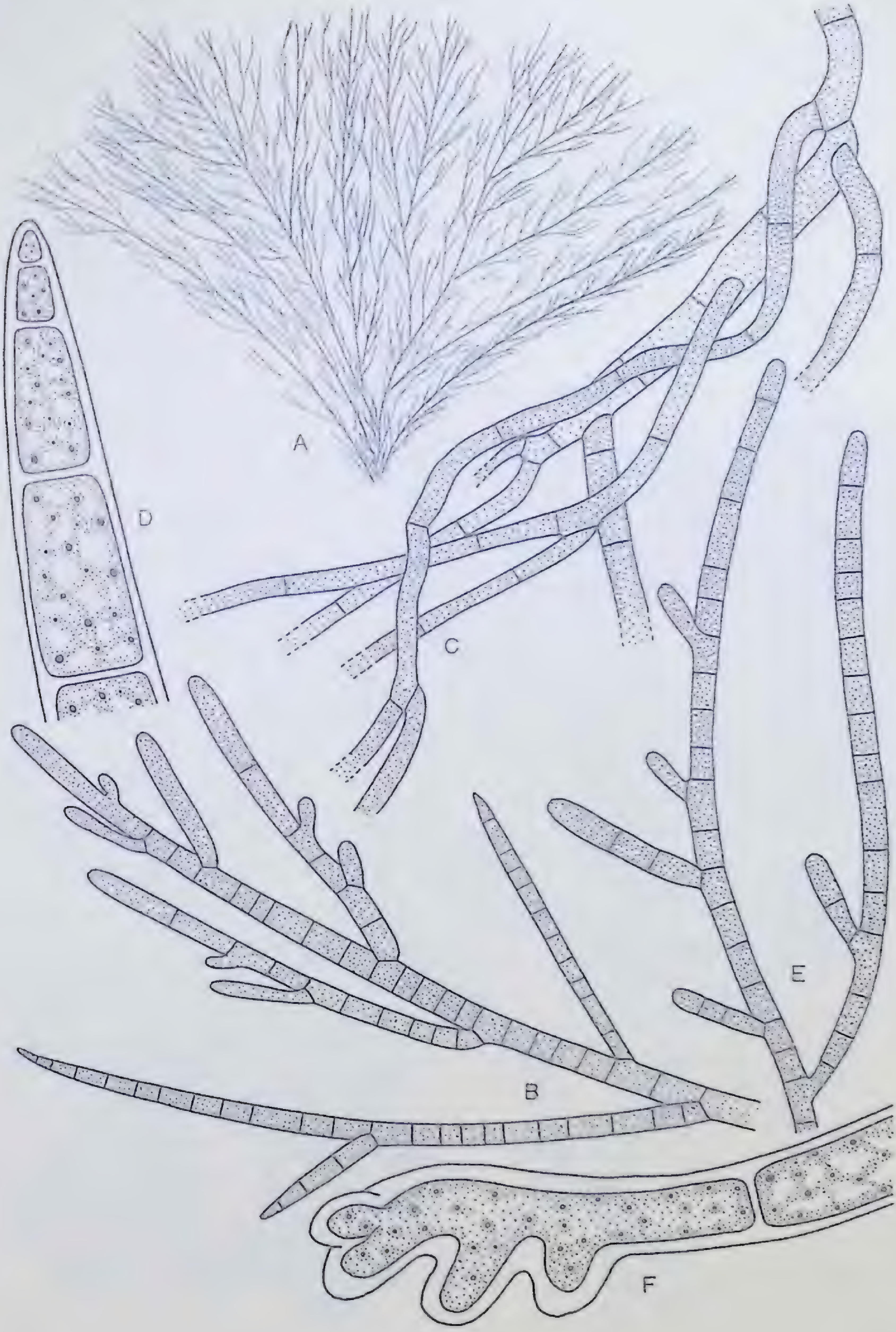

PLATE 42

Spongomorpha spinescens Kützing

A. Habit, X 1.
B. Portion of thallus in basal region showing branchlets and rhizoid, X 75.
C. Detail of rhizoidal filament showing septate holdfast, X 500.
D. Apical region of distal part of thallus, X 240.
E. Portion of thallus showing lateral branches, X 45.
F. Portion of thallus showing lateral branch, X 45.
G, H. Simple branchlets, X 115.
I. Portion of filament showing detail of chloroplast, X 500.

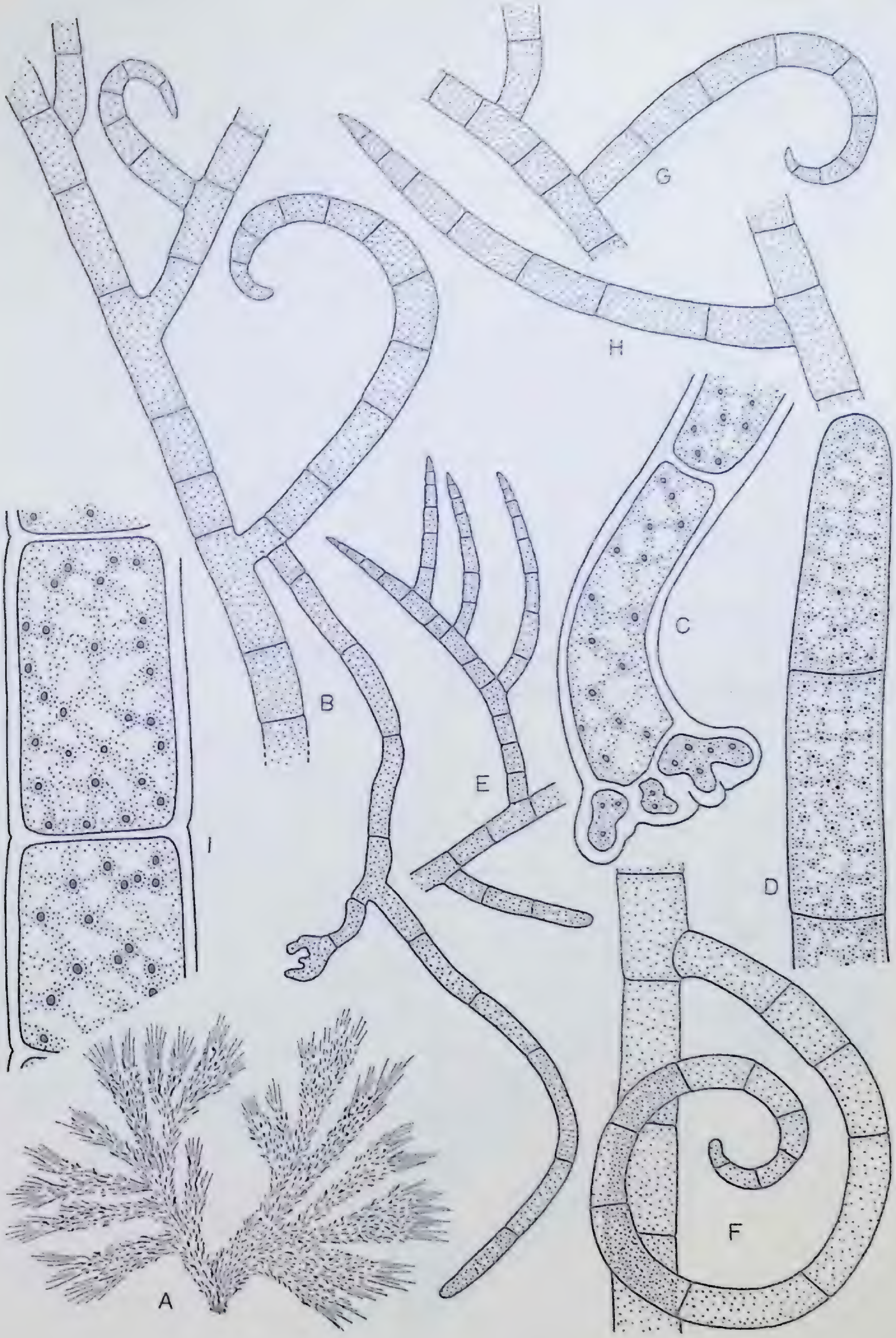
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PLATE 43

Cladophora albida (Hudson) Kützing

A. Apex of terminal cell of branchlet, X 500.
B. Branching habit in distal portion of plant, X 330.

Cladophora flexuosa (Griffiths) Harvey

C. Terminal cell of branchlet, X 375.

Cladophora gracilis (Griffiths) Kützing

D. Apex of terminal cell of branchlet, X 720.

Cladophora laetevirens (Dillwyn) Kützing

E. Apex of terminal cell of branchlet, X 45.

PLATE 43

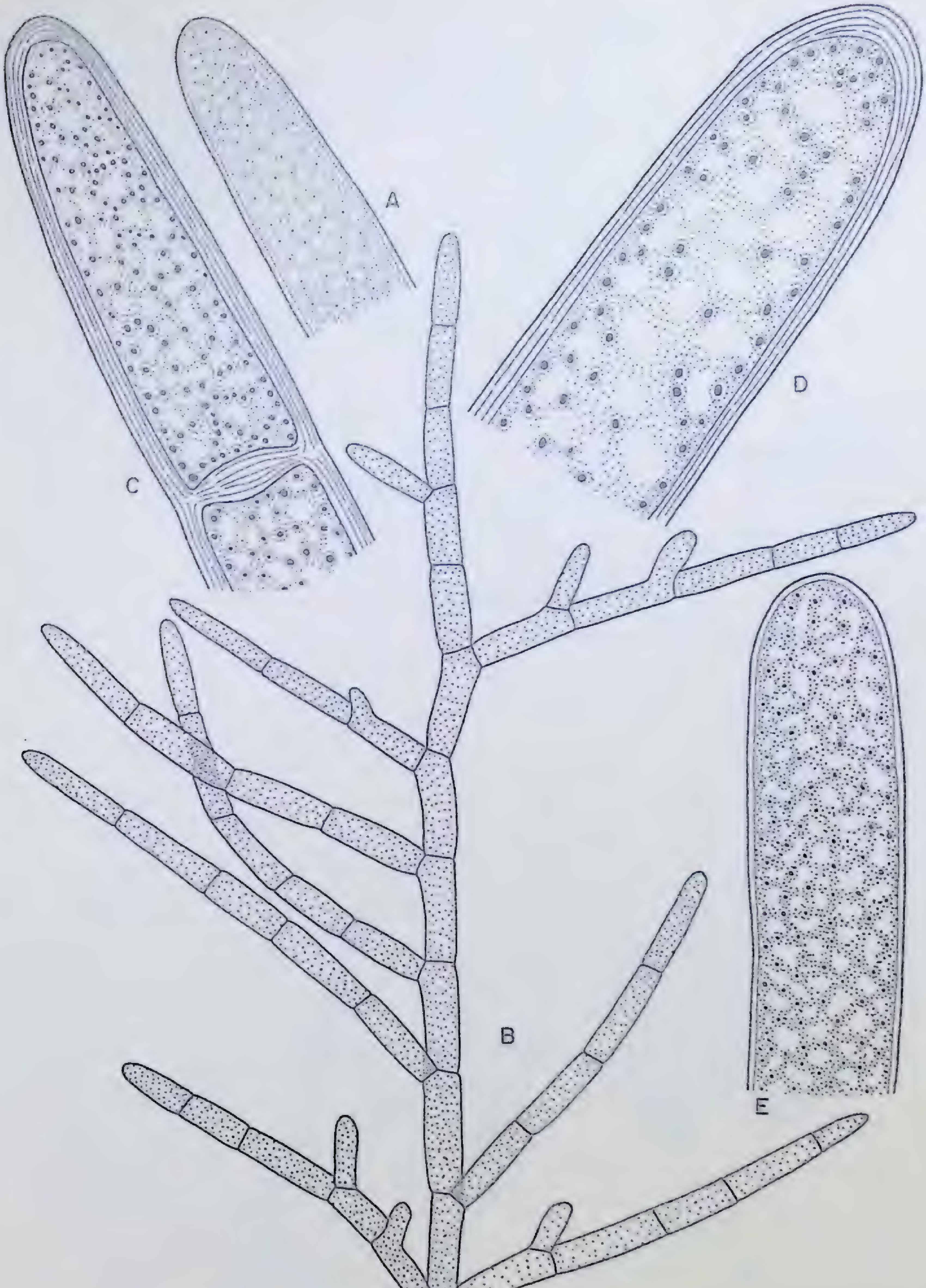


PLATE 44

Cladophora flexuosa (Griffiths) Harvey

A. Branching habit in distal portion of plant, X 50.

Cladophora glaucescens (Griffiths) Harvey

B. Branching habit in distal portion of plant, X 115.
C. Terminal cell of branchlet, X 720.

Cladophora hutchinsiae (Dillwyn) Kützing

D. Portion of thallus showing branches, X 50.

PLATE 44

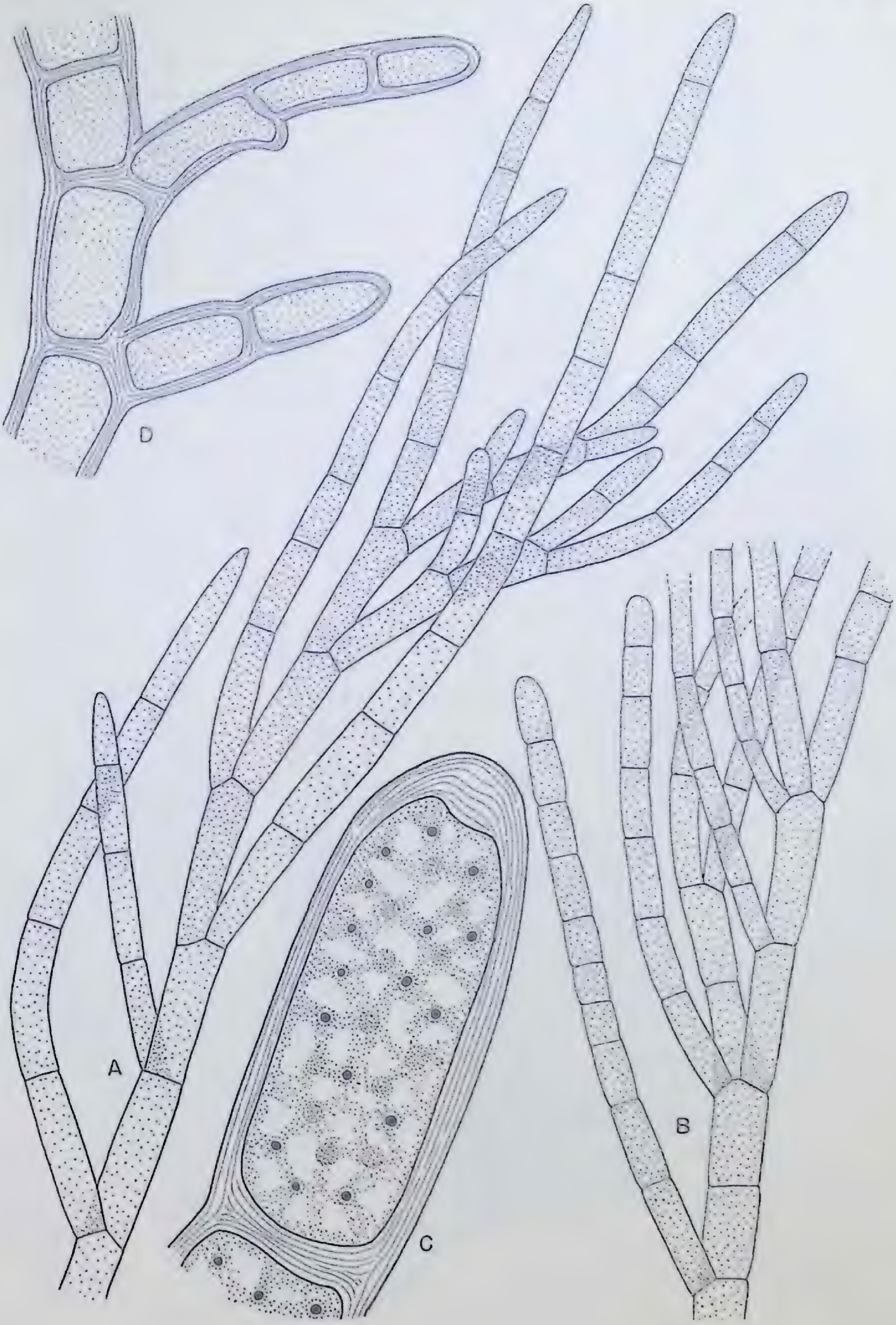


PLATE 45

Cladophora glaucescens (Griffiths) Harvey

A. Branching habit in distal portion of plant, X 115.
B. Fertile portion of filament showing discharge pore at upper end of one cell, X 500.
C. Detail of cell in vegetative condition, X 1080.

Cladophora hutchinsiae (Dillwyn) Kützing

D. Branching habit in distal portion of plant, X 330.

PLATE 45

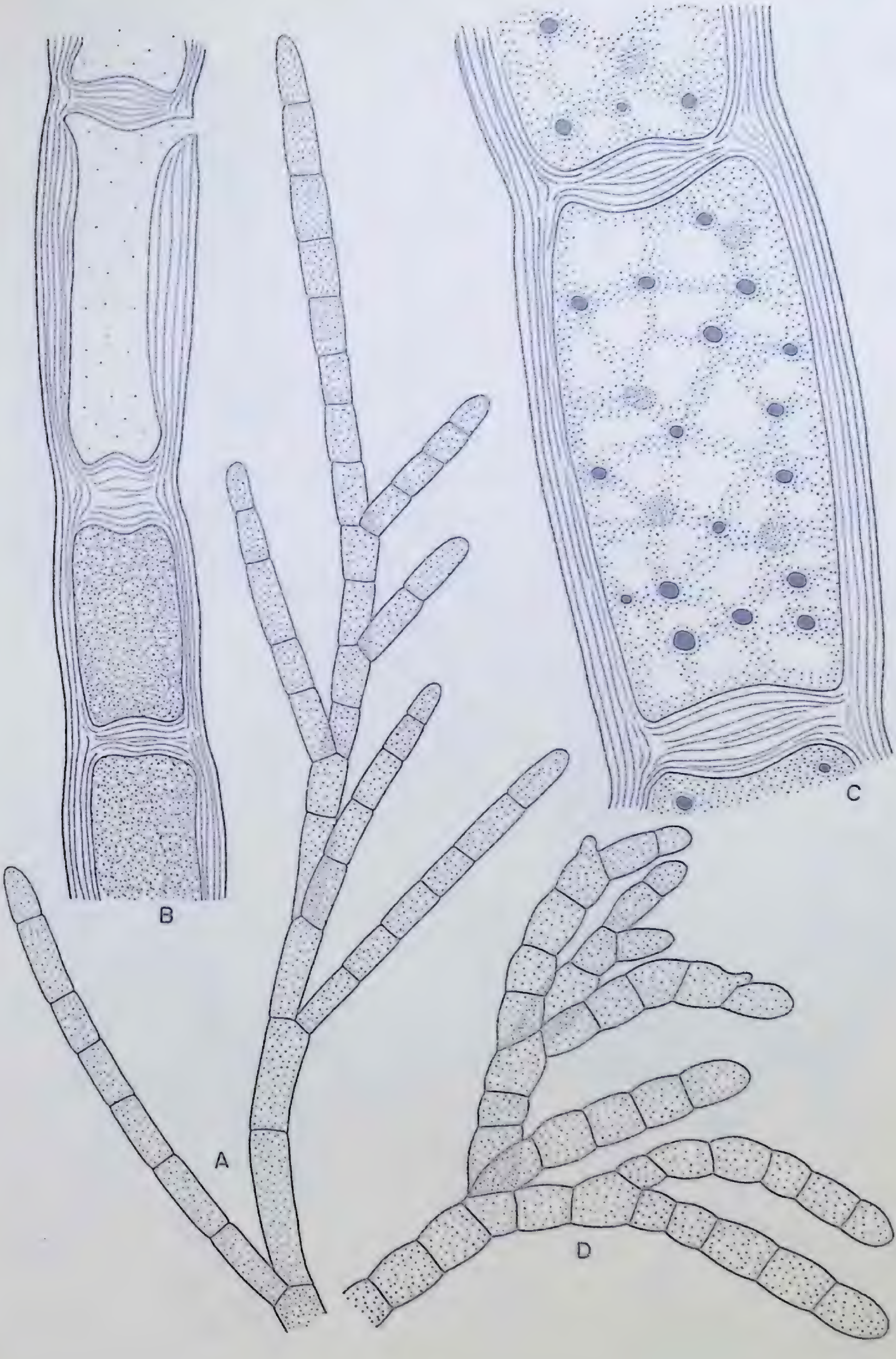


PLATE 46

Cladophora gracilis (Griffiths) Kützing

A. Branching habit in distal portion of the plant, X 75.

Cladophora hutchinsiae (Dillwyn) Kützing

B. Distal portion of branched filament showing several fertile cells and one empty cell with a discharge pore, X 50.
C. Portion of rhizoidal holdfast cell, X 500.
D. Surface view of a portion of the cell showing detail of chloroplast, X 500.

Cladophora stimpsonii Harvey

E. Apex of terminal cell of a branchlet, X 1080.

PLATE 46

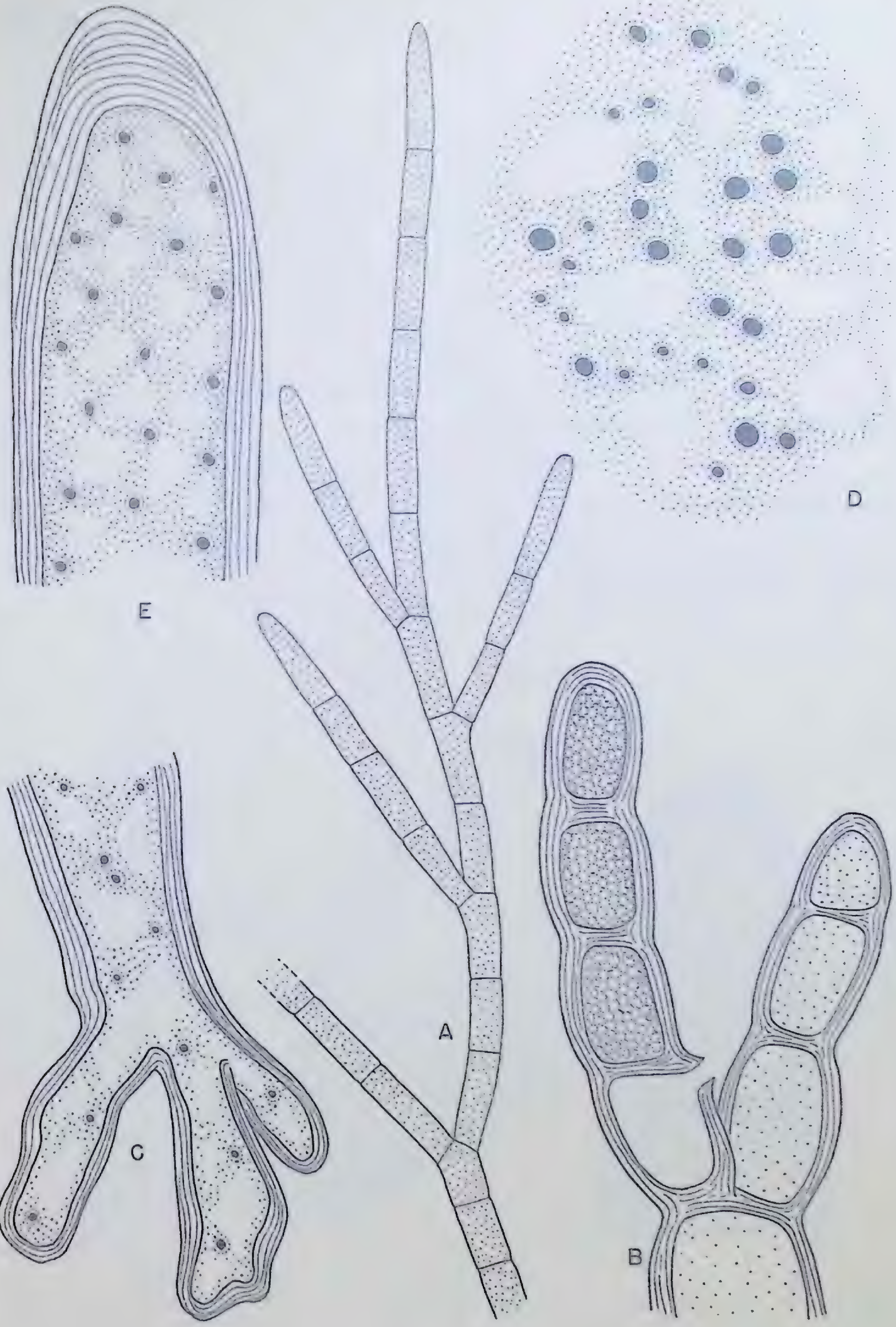


PLATE 47

Cladophora laetevirens (Dillwyn) Kützing

A. Branching habit in distal portion of thallus, X 30.

Cladophora microcladioides Collins

B. Branching habit, showing determinate axis with branchlets, X 75.

Cladophora trichotoma (C. Agardh) Kützing

C. Terminal cell of a branchlet, X 240.

PLATE 47

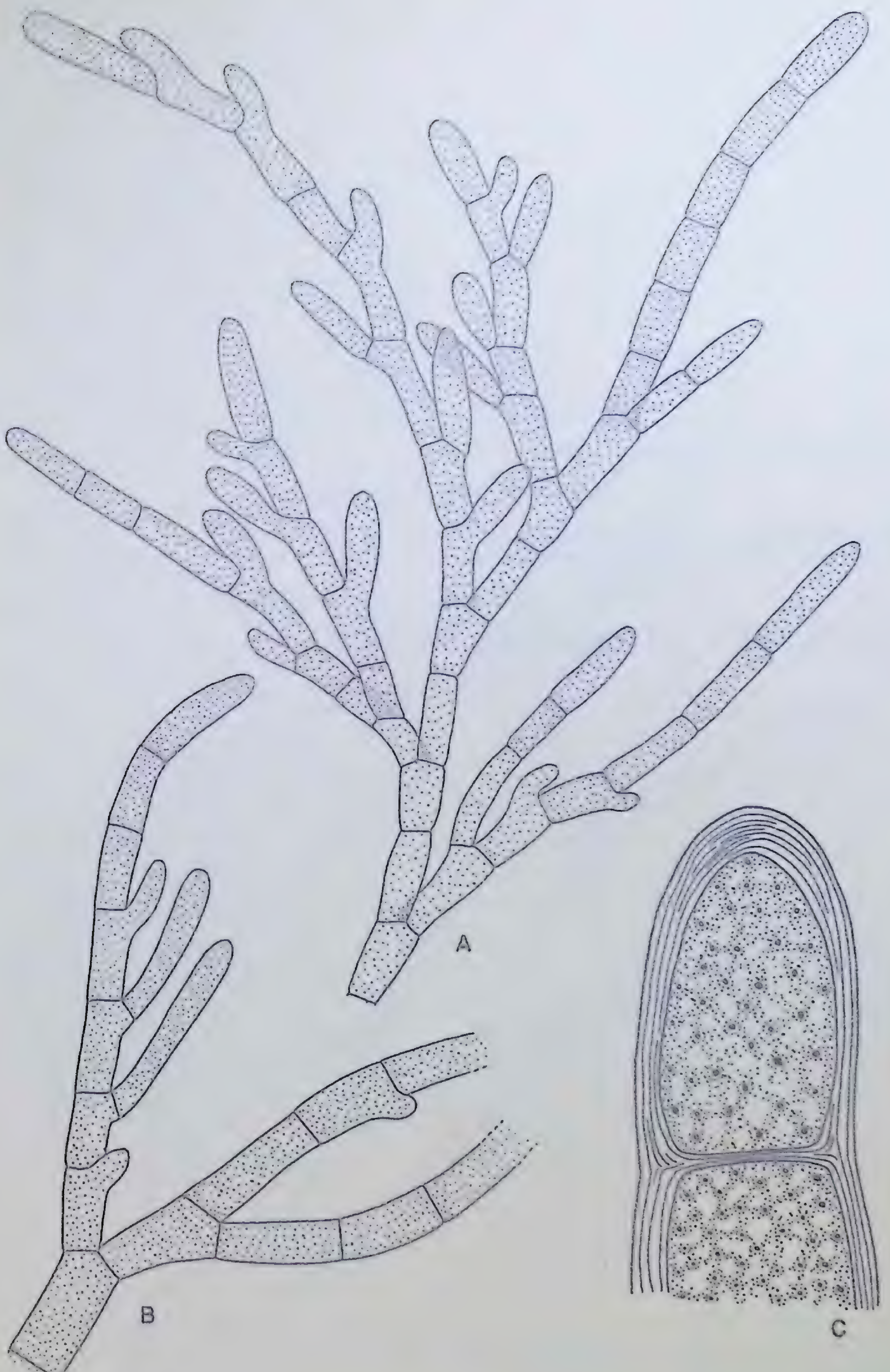


PLATE 48

Cladophora microcladioides Collins

A. Terminal cell of a branchlet, X 375.

Cladophora stimpsonii Harvey

B. Terminal portion of a branchlet, X 115.
C. Branching habit in distal portion of thallus, X 50.

Cladophora trichotoma (C. Agardh) Kützing

D. Branching habit in distal portion of the thallus, X 50.

PLATE 48

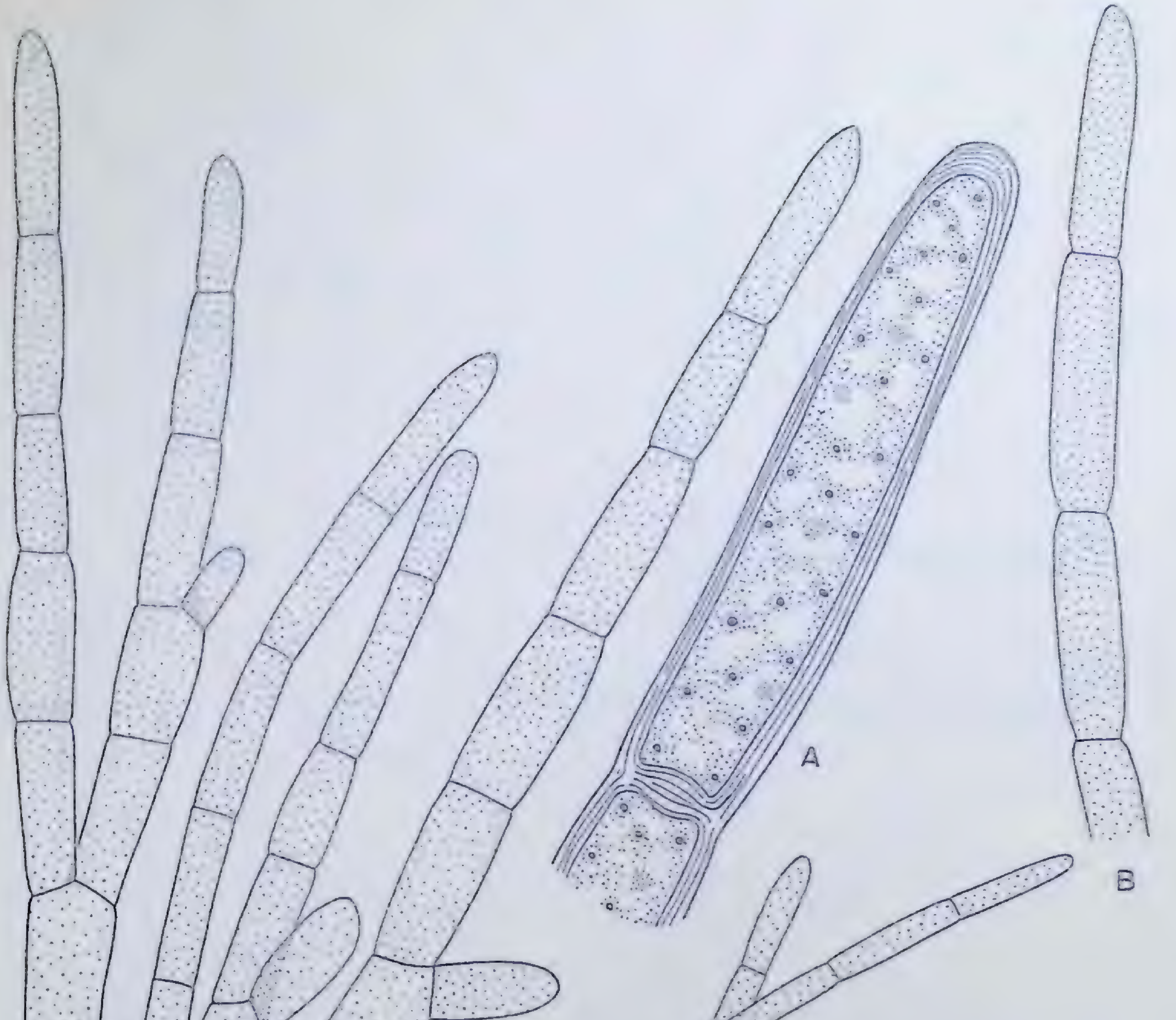


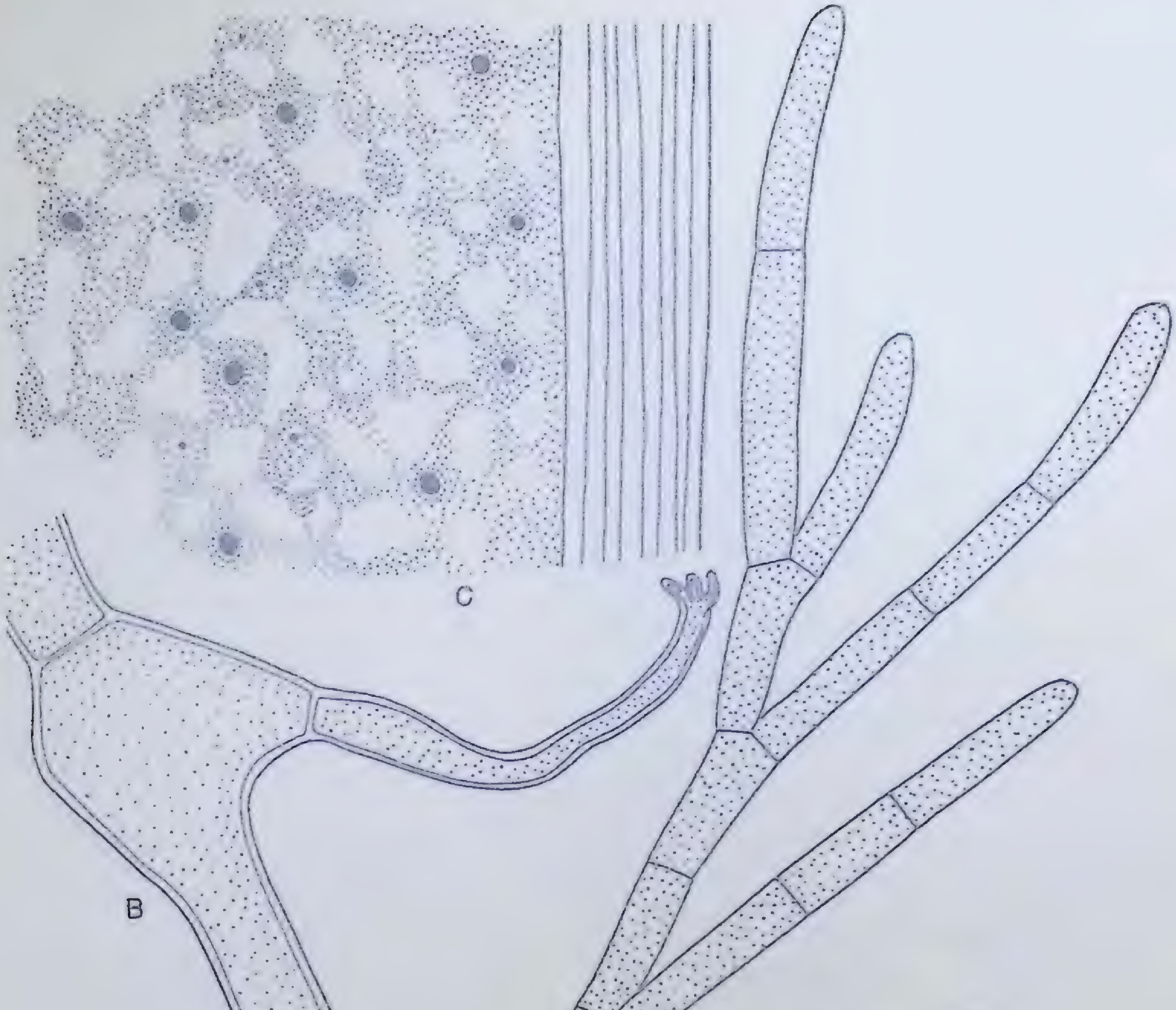
PLATE 49

Cladophora microcladioides Collins

A. Branching habit in distal portion of thallus, X 115.

Cladophora trichotoma (C. Agardh) Kützing

B. Basal portion of filament showing rhizoidal cell, X 75.
C. View of a portion of the cell showing thick, lamellose cell walls and detail of part of the chloroplast, X 1080.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